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Exploration Geophysics

0920 Magnetic and electrical methods
ELECTROMAGNETIC MODELING OF THREE-DIMENSIONAL BODIES IN LAYERED EARTHS USING INTEGRAL EQUATIONS
Philip E. Wannamaker (Earth Science Laboratory, University of Utah Research Institute, 420 Chipeta Way, Ste. 120, Salt Lake City, UT 84108) Gerald W. Hohmann, and William A. SanFilipo

We have developed an algorithm based on the method of integral equations to simulate the electromagnetic responses of three-dimensional bodies in layered earths. The inhomogeneities are replaced by an equivalent current distribution which is approximated by pulse basis functions. A matrix equation is constructed using the electric tensor Green's function appropriate to a layered earth, and it is solved for the vector current in each cell. Subsequently, scattered fields are found by integrating electric and magnetic tensor Green's functions over the scattering currents.

Efficient evaluation of the tensor Green's functions is a major consideration in reducing computation time. We find that tabulation and interpolation of the six electric and five magnetic Hankel transforms defining the secondary Green's functions is preferable to any direct Hankel transform calculation using linear filters.

A comparison of responses over elongate three-dimensional (3-D) bodies with responses over two-dimensional (2-D) bodies of identical cross-section using plane wave incident fields is the only check available on our solution. Agreement is excellent; however, the length that a 3-D body must have before departures between 2-D transverse electric and corresponding 3-D signatures are insignificant depends strongly on the layering. The 2-D transverse magnetic and corresponding 3-D calculations agree closely regardless of the layered host.
GEOPHYSICS, VOL. 49., NO. 1

0920 Magnetic and electrical methods
DOES DRAPING AEROMAGNETIC DATA REDUCE TERRAIN-INDUCED EFFECTS?
V.J.S. Grauch (U.S. Geological Survey, Box 25046, MS 964, Denver Federal Center, Denver, CO 80225) David Campbell

Contrary to intuition, draped aeromagnetic surveys (when compared to typical level surveys) amplify, rather than reduce, the problem of magnetic-terrain anomalies. Calculations of the total magnetic field of various simple magnetic topographies on level and draped surfaces support this conclusion. In cases where draped surfaces are lower than level surfaces, the draped profiles exhibit steeper gradients and deeper polarity lows over topography than do the level profiles. On the other hand, where draped surfaces are higher than level surfaces, *all* anomalies are attenuated, so that magnetic-terrain effects might be reduced relative to subsurface sources (depending upon the magnetization of each).

The difference in magnetic behavior between level and draped data can be explained by a contribution of a vertical derivative component in the draped case that is absent in the level case. The contribution is most significant near topographic features because both the observation surface and the topographic surface are changing vertically.
GEOPHYSICS, VOL. 49., NO.1

0930 Seismic methods
MODELING THE EFFECT OF STATIC ERRORS IN AREAL SEISMIC DATA CAUSED BY GLACIAL EROSION OVER CARBONATE REEFS
Janet E. Kotcher (Gulf Research and Development Co., P. O. Drawer 2038, Pittsburgh, PA 15230) G. H. F. Gardner, and John A. McDonald

An effective way of exploring for structural features is by areal seismic methods. In addition to finding depth and location, the area of a structure may be determined at a reasonable cost. However, the efficacy of the areal method can be rapidly destroyed by static shifts in the seismic traces. In this paper, we investigate the effect of statics on the crossed array method of areal data collection. Seismic data were collected in the northern Michigan reef trend, an area containing numerous small pinnacle reefs. The surface topography is flat, but it contains deep erosional valleys filled with glacial drift which produce time shifts in the data. The data were processed without static corrections. To predict the effect of static errors, a model was designed to produce data resembling those taken over a pinnacle reef. Seismic data were collected over this model by a method simulating the crossed array technique. Horizontal displays of the power envelope and the instantaneous phase of the migrated data were generated at a specified one-way time, when various source and receiver dependent statics had been introduced into the raw data. The statics were designed to simulate the effect of glacial drift. If the diameter of the migration aperture is significantly larger than the distance along the source and receiver lines affected by statics, the effect on the migrated output is minimal. However, if the distance affected by statics approaches the diameter of the migration aperture, the effects are significant.
GEOPHYSICS, VOL. 49, NO. 1

0930 Seismic methods
CROSS-HOLE SEISMIC SURVEYS: APPLICATIONS FOR STUDYING SUBSURFACE FRACTURE SYSTEMS AT A HOT DRY ROCK GEOTHERMAL SITE
Michael Fehler (Geophysics Group, Oregon State University, Corvallis, OR 97331) Chris Pearson

The use of cross hole seismic surveys for delineating the location and size of subsurface fracture systems is investigated. The radiation pattern for *P* and *S* waves emitted by a seismic source in a borehole is derived. Experimental work in relatively homogeneous granite suggests that the derived relationship adequately describes the radiation patten for both explosive sources and acoustic transducers placed in fluid-filled boreholes.

Using the above functional expressions for the *S*- and *P*-wave amplitudes, we have developed a technique to estimate *Q* and locate discrete fractures in crystalline rock that compose the Hot Dry Rock Geothermal Reservoir at Fenton Hill, New Mexico. To calculate *Q*, we measure the *P*- and *S*-wave amplitudes as a function of distance from the source, compensate for the radiation pattern and geometrical spreading effects, and match the relative attenuation to a function of the form exp (−π R/QV) using a least-squares regression technique. For undisturbed parts of the reservoir, we obtain values of *Q* on the order of 160 for *P* waves and from 170 to 150 for *S* waves. Using our method we are able to detect a decrease in the average *Q* due to extensive fracturing following heat extraction from the Fenton Hill reservoir.

We have also been able to locate discrete large-scale fractures in the reservoir by noting regions characterized by a sudden change in signal amplitude, waveform or frequency content that cannot be explained by radiation pattern effects or increases in source-receiver separation. These localized attenuating regions in the Fenton Hill Hot Dry Rock reservoir are probably open fractures.
GEOPHYSICS, VOL. 49., NO. 1

0930 Seismic methods
ACCOMMODATING LATERAL VELOCITY CHANGES IN KIRCHHOFF MIGRATION BY MEANS OF FERMAT'S PRINCIPLE
Jerry A. Carter (Formerly Hawaii Institute of Geophysics, Honolulu; presently Rondout Associates Inc., P.O. Box 224, Stone Ridge, NY 12484) L. Neil Frazer

When velocity varies laterally as well as with depth, an exact Kirchhoff depth migration requires that rays be traced from each depth point in the section to each source/receiver location. Because such a procedure is prohibitively expensive, Kirchhoff migration is usually carried out by using a velocity function that depends only on depth. This paper introduces a new method, based on Fermat's principle, which is a compromise between these two extremes. The slowness (reciprocal velocity) function is written as the sum of two functions, the first of which is large and depends only on depth, while the other is small and varies both with depth and position along the line. Raypaths are traced for the first slowness function and are used to calculate migration curves. For each depth point these same raypaths are used to calculate traveltime perturbations [illegible] due to the laterally varying part of the slowness. The traveltime perturbations are added to the migration curve to obtain an approximation to the exact migration curve. More precisely, suppose that the slowness function can be written in the form $a(z) + b(x, z)$ where $|b| \ll a$. Using $a(z)$, we generate a table giving two-way traveltime T as a function of scatterer depth z and surface offset Δ, and a raypath table which gives the ray offset ξ as a function of scatterer depth, surface offset, and ray depth ζ. For fixed z, $T(\Delta z)$ is a migration curve and conventional Kirchhoff migration of zero-offset reflection data $\psi(x,t)$ is performed by summation along such curves: $\psi(x,t) \to \psi(x,z)$ by

$$\psi(x,z) = \int W \partial_t^{1/2} \psi\left[x+\Delta, T(\Delta, z)\right] d\Delta$$

where W is a weighting factor. The raypath table is used to calculate the traveltime perturbation

$$T_p(x, \Delta, z) = \int b(x+\xi, \zeta)\, d\sigma$$

where the integral is taken over the unperturbed raypath. For fixed x and z the new migration is performed by

$$\psi(x,z) = \int W \partial_t^{1/2} \left[x+\Delta, \tau(x, \Delta, z)\right] d\Delta$$

This new migration scheme is much less expensive than the exact Kirchhoff scheme because only one set of rays need be traced. Numerical tests have shown that this scheme works surprisingly well even when the lateral variation of velocity is large.
GEOPHYSICS, VOL. 49, NO. 1

0930 Seismic methods
RADIATION FROM A DOWNHOLE AIR GUN SOURCE
Myung W. Lee (U.S. Geological Survey, Box 25046, MS 960, Denver Federal Center, Denver, CO 80225) Alfred H. Balch, and Kenneth R. Parrott

This paper describes some characteristics of a downhole air gun as a source of seismic energy for a vertical seismic profiling (VSP) experiment at Salt Valley, Utah. The major emphasis is on primary radiations from the air gun source and secondary *radiations* from the bottom of the source hole.

The observed primary radiation pattern agrees very well with theory developed for a volume displacement source acting on the axis of a fluid-filled hole. The observed secondary radiations, whose amplitudes were much stronger than the primary radiations, can be explained by calculating the wave field resulting from the application of an equivalent point force in an infinite medium, which was caused by the reflection of a tube wave at the bottom of the source hole.

The experimental data also indicate that high-amplitude compressional and shear wave multiples are generated between the bottom of the source hole and the air bubble.
GEOPHYSICS, VOL. 49., NO. 1

0930 Seismic methods
AN ANALYSIS LEADING TO THE REDUCTION OF SCATTERED NOISE ON DEEP MARINE SEISMIC RECORDS.
C. James Tsai (Texaco USA, P.O. Box 425, Bellaire, TX 77401)

The rough and uneven basaltic basement in deep water environments functions as a potential source of scattering. The source-generated noise not only interferes with the weak and deep primary reflections, but often resembles primary reflections, thereby confusing the seismic interpretation.

An analysis of the arrival time of scattered noise indicates that NMO and apparent dip of scattered noise exhibit azimuth dependency. For isotropic scattering, in-line scattering at ranges near 0 degree azimuth and sideswipe from 90 degree azimuth should dominate the seismic section. Actual marine data displayed in various data gathers illustrate these characteristics of scattered noise and also correct a common misconception about the appearance of scattered noise. The analysis suggests the use of CDP stacking and velocity filtering to attenuate the scattered noise. The combined effect shows a total reduction of scattered noise by [illegible] the frequency bandwidth from 20 to 32 Hz.
GEOPHYSICS, VOL. 49., NO. 1

News

Earth Sciences Priorities

Priority research areas for the solid earth sciences were recently identified by two blue-ribbon panels. Each suggested specific areas where funds should be targeted for rapid advances in expanding our knowledge of the earth and for long-term payoffs both in basic research and in training the next generation of earth scientists.

In its report released last week, the Research Briefing Panel on the Solid Earth Sciences identified five priority research topics. In a report issued earlier this year, the Committee on Opportunities for Research in the Geological Sciences selected for top billing eight such research areas. The common scientific thread running through both reports: More research is needed on the structure, composition, and evolution of the continental lithosphere and on the dynamics of tectonic processes.

The Research Briefing Panel on the Solid Earth Sciences (see box), was formed by the Committee on Science, Engineering, and Public Policy (COSEPUP) of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The panel prepared its report for the Office of Science and Technology Policy (OSTP), NSF, and selected federal departments and agencies. OSTP Director George A. Keyworth, II, who also is President Ronald Reagan's science advisor, is a long-time advocate of setting priorities for research support (*Eos*, May 10, 1983, p. 371) and has repeatedly praised the National Research Council's (NRC) Astronomy Survey Committee for setting out its priorities last year in what is commonly called the "Field Report," after committee chairman George B. Field (*Eos*, May 18, 1982, p. 506).

The Committee on Opportunities for Research in the Geological Sciences (see box) was formed by the NRC Board on Earth Sciences (BES) at the request of James F. Hays, director of the division of earth sciences of the National Science Foundation (NSF). Hays requested the BES, formerly the Geological Sciences Board, to report on "the state of science and to recommend policy for the decade of the 90's relevant to the academic community and ~~NSF.~~ The resulting report, *Opportunities for Research in the Geological Sciences*, emphasizes earth science research that has "typically been supported" by NSF. NSF provides 90% of all federal funds going to colleges and universities for basic geological sciences research. Among the relevant reports on which the COSEPUP briefing panel based its recommendations was the BES committee report.

The COSEPUP briefing panel identified five topics that would be likely to yield significant scientific payoffs with increased funding in fiscal year (FY) 1985; the BES committee looked at FY 1985 and ahead to FY 1990. President Reagan will send his proposed budget for FY 1985 to Congress by mid February. The briefing panel's report "emphasizes areas that lie on the frontiers of earth sciences . . . and describes some of the conceptual and technical advances that make it possible to explore more fully the third and fourth dimensions, depth and time." The five areas are

- seismic investigations of the continental crust
- continental scientific drilling
- physics and chemistry of geological materials
- global digital seismic array
- satellite geodesy.

Of the specific projects recommended, some "such as deep continental drilling, determination of the continental geoid, and crustal seismic reflection, can proceed immediately if resources are made available," the panel says. "Others, such as large seismic arrays, expanded isotopic exploration of the crust and mantle, monitoring of crustal motions, and the study of chemistry and physics of geological materials, require major investments in modern facilities."

The BES committee, on the other hand, identified eight areas "having the most promise for advancing geology in the next decade." With the exception of the first topic listed, no significance is intended by the order. The eight areas are

- more detailed and accurate definitions of the structure and composition of the continental lithosphere, including the continental margins
- quantitative models for sedimentary basin evolution
- improved understanding of magma generation and emplacement
- knowledge of the physical and chemical properties of rocks
- a better understanding of tectonic processes, the physical and chemical states that produce them, and the structures that result
- a model of convection in the earth's interior
- evolution of life
- surficial processes.

While the COSEPUP briefing panel did not make specific funding recommendations, the BES committee did. "In our view," the committee report states, "an appropriate response to the needs of the field would require an annual increment of $21 million to the President's 1984 budget." President Reagan's fiscal 1984 budget proposal for the earth sciences division was $42 million (*Eos*, February 15, 1983, p. 65). By fiscal 1990, the BES committee report continues, "a goal of an additional $53 million over the 1984 budget for NSF's Division of Earth Sciences is a justifiable and realizable goal." The committee recognized, however, that "funding recommendations for FY 1990 are naturally more speculative." Among the initiatives suggested by the BES committee are a program of continental drilling (with a suggested funding level of $4 million in FY 1985 and $20 million in FY 1990). Funding for seismic reflection studies should be be doubled, in the committee's view.—*BTR*

Solid Earth Sciences Panel

Charles R. Drake of Dartmouth College (and AGU President-Elect) and Don L. Anderson of the California Institute of Technology cochaired the COSEPUP Research Briefing Panel on the Solid Earth Sciences.

Members of the panel were William R. Dickinson, Univ. of Arizona; Carl Kisslinger, CIRES, Univ. of Colorado; John C. Maxwell, Univ. of Texas at Austin; V. Rama Murthy, Univ. of Minnesota; Jack E. Oliver, Cornell Univ.; C. Barry Raleigh, Lamont-Doherty Geological Observatory; Frank M. Richter, Univ. of Chicago; Eugene M. Shoemaker, U.S. Geological Survey; Edward Stolper, CalTech; and Peter J. Wyllie, CalTech.

Committee on Opportunities for Geological Research

William R. Dickinson of the University of Arizona chaired the Committee on Opportunities for Research in the Geological Sciences, appointed in mid 1982 by the National Research Council's Board on Earth Sciences (formerly the Geological Sciences Board).

Committee members were Samuel S. Adams, Adams and Associates, Boulder, Colo.; Clarence R. Allen, California Institute of Technology; John C. Crowell, Univ. of California, Santa Barbara; Charles R. Drake, Dartmouth College; John C. Harms, Harms and Brady, Littleton, Colo.; William W. Hay, Univ. of Colorado; Carl Kisslinger, CIRES, Univ. of Colorado; V. Rama Murthy, Univ. of Minnesota; Allison R. Palmer, Geological Society of America; and David B. Stewart, U.S. Geological Survey. Liaison members were Robin Brett, NSF (until September 30, 1982); [illegible] James F. Hays, NSF (after October 1, 1982); and [illegible] Geological Institute. [illegible]

Lithospheric Seismology

An open meeting will be held at the Lahara Convention Center in Madison, Wis., January 13–14, 1984, to formulate the organizational plan for an institutionally based consortium for lithospheric and other portable array seismology. It is hoped that participants will represent a wide spectrum of geophysics and geology to assure that the plan which emerges from the meeting reflects a broadly based consensus of the earth science community.

A new national program is being initiated whose goal is to acquire a minimum of 1000 matched, portable digital seismographs for carrying out high resolution, 3-dimensional seismic imaging of the continental lithosphere to depths well into the upper mantle. Present design plans call for microprocessor-based, multi-component seismographs capable of programmed or triggered recording of earthquakes (including teleseisms) and artificial sources over user-selected bandwidth(s) within the range 0.01 to 200 Hz. The instruments are expected to be modular and of sufficient versatility that they can be used to address a diverse range of scientific problems (from microseismicity to surface wave tomography to deep earth structure) in addition to continental lithospheric imaging.

Those interested in attending the Madison meeting may obtain further information by writing to Organizing Committee, CIW/DTM, 5241 Broad Branch Rd., N.W., Washington, DC 20015, or by calling David James (202-966-0863) or Bob Meyer (608-262-1698).

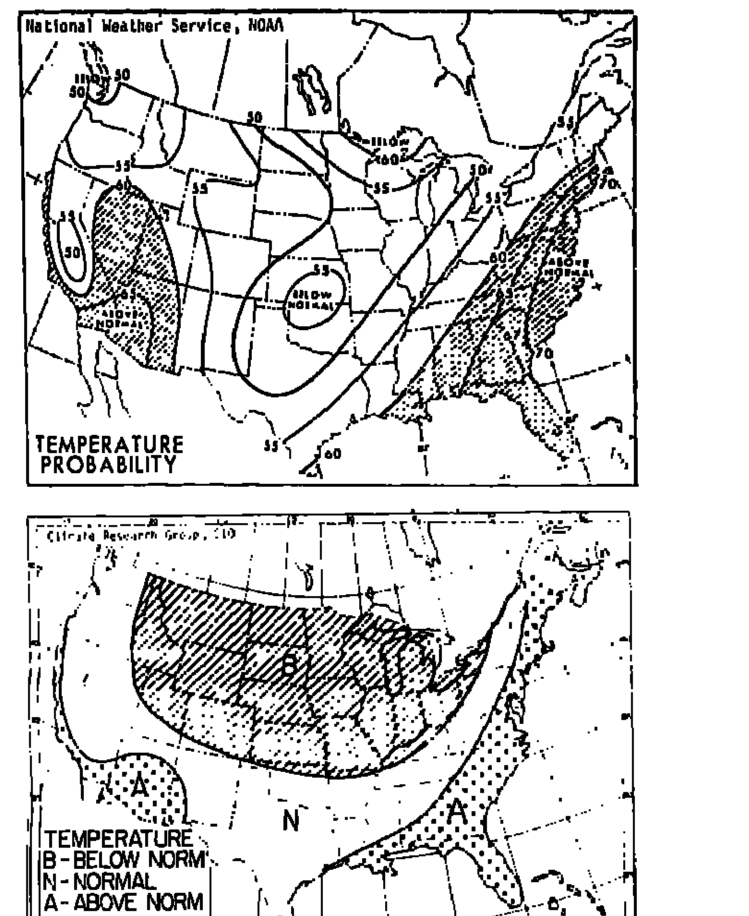

Fig. 1. Temperature predictions for the 1983–1984 winter, defined as December through, and including, February. *(top)* The National Weather Service winter outlook uses probability contours. *(bottom)* Prediction made by Jerome Namias and Daniel Cayan of the Scripps Institution of Oceanography (SIO) uses the above-normal, below-normal, and normal labels.

Winter Weather Forecast

A milder-than-normal winter is predicted for the eastern and western extremes of the United States, while the country's midsection can expect colder than normal temperatures, according to the winter weather outlook issued November 28 by the National Oceanic and Atmospheric Administration's National Weather Service (NWS). The outlook (Figure 1, top), which covers December, January, and February, also predicts that the Northwest, Midwest, and the lower Mississippi valley can expect greater than normal precipitation (Figure 2, top).

Independently, researchers with the Climate Research Group at the Scripps Institution of Oceanography (SIO) issued their winter weather forecast on November 29. While the temperature outlook by Jerome Namias and Daniel Cayan (Figure 1, bottom) shows a similar—though not identical—pattern to the NWS prediction, the SIO researchers' precipitation prediction (Figure 2, bottom) is very different from the NWS one.

Donald L. Gilman, chief of the NWS predictions branch, said that the probabilities of a warmer than normal winter exceed 55% in the East and South, rising through 60% along the Appalachian Mountains to at least 65% on the east coast from Florida to Massachusetts. The probabilities of warmer than normal temperatures reach a maximum of 70% from South Carolina to Long Island. Except for the extreme Northwest and interior California, the probability of a relatively warm winter exceeds 55% everywhere west of the Continental Divide. The probabilities of nor-

News (cont. on p. 986)

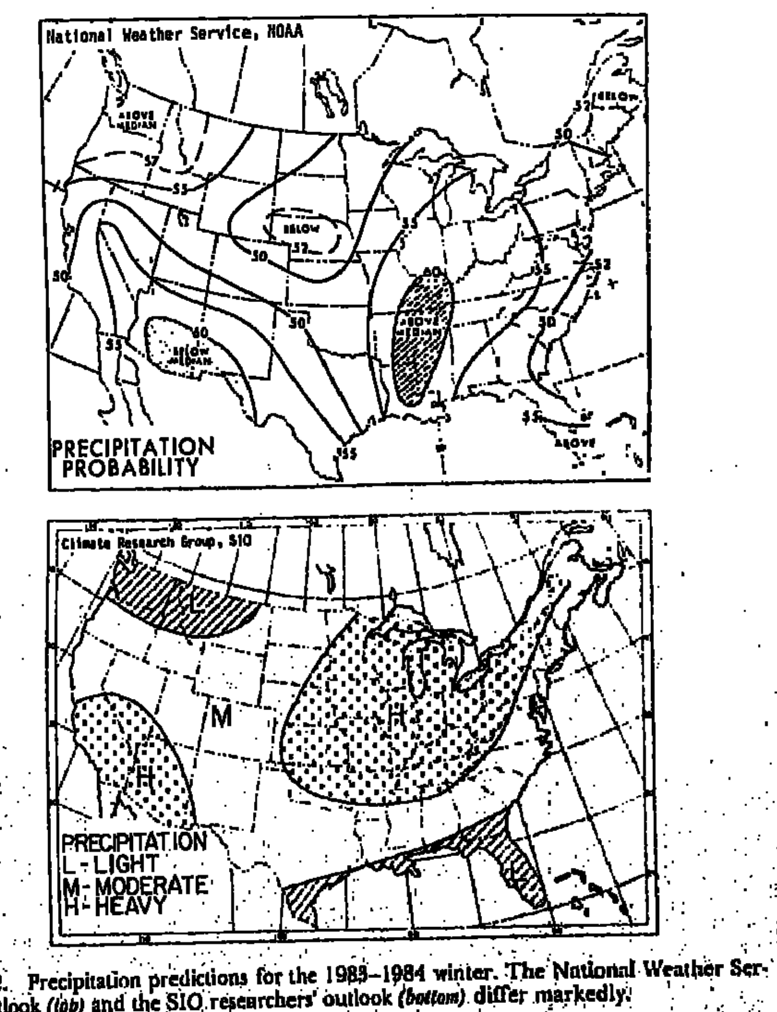

Fig. 2. Precipitation predictions for the 1983–1984 winter. The National Weather Service outlook *(top)* and the SIO researchers' outlook *(bottom)* differ markedly.

News *(cont. from p. 985)*

mal temperatures exceed 60% in Nevada, the far Southwest, and on the California coast. They peak at 65% in the Arizona-Southern California sunbelt. NWS has been using probabilities in their long-range forecasts since July 1982.

Little evidence supports any clear temperature patterns for the remainder of the midwest and Great Plains and for the Pacific Northwest, Gilman said.

Similarly, Namias and Cayan say that temperatures are expected to approach normal in the far West, with slightly warmer-than-normal temperatures in areas along coastal California, southern California, and southern Arizona. Normal winter temperatures are expected for the far Northwest, much of California, Nevada, Utah, northern Arizona, New Mexico, Texas, Oklahoma, Arkansas, and a narrow band of states extending through the region west of the Appalachians. The SIO researchers say that above-normal temperatures are expected along the southern Gulf Coast states and the eastern seaboard.

NWS predicts a 55% probability of above-normal precipitation in the Northwest, Midwest, and lower Mississippi valley, except for a 60% chance near the lower Mississippi River. Chances of below-normal precipitation are 60% from the Big Bend to southern Arizona, Gilman said. In the southest from the Rio Grande Valley through New Mexico and Arizona to the central and southern ranges of the Sierra Nevada, there is a 55% chance of below-normal precipitation.

Namias and Cayan, on the other hand, predict less-than-normal amounts of precipitation to fall in the Northwest, along the Gulf Coast, and in Florida. Heavy precipitation is anticipated for the southern half of California, Nevada, and southern Arizona. The researchers do not expect the Pacific storms that penetrate the west coast to match the frequency or intensity of last winter's battering storms. Heavier than normal precipitation also is predicted from the midwest to the Appalachian Mountains.

Books

Oceanography: The Past

M. Sears and D. Merriman (Eds.), Springer-Verlag, New York, xx + 812 pp., 1980, $39.80.

Oceanography: The Present and Future

P. G. Brewer (Ed.), Springer-Verlag, New York, xii + 392 pp., 1983.

Reviewed by Arnold L. Gordon

Oceanography is a young science, close to its historical roots, but it's maturing fast as "state-of-the-art" technology and computer-aided numerical modeling play an increasing role. Our ability to obtain, process, and analyze enormous volumes of data would stun an oceanographer of the 1930's. (I hope he would be equally impressed by the quality of modern data.) The Third International Congress on the History of Oceanography and the celebration of the 50th anniversary of the Woods Hole Oceanographic Institution (WHOI) were both held in September 1980 at WHOI; and both events were taken as an opportunity to improve our understanding of the past and present of oceanography, and future of the ocean sciences with the thought that we could thereby better influence future trends.

Two books resulted from the presentations at the September 1980 meetings at WHOI: *Oceanography: The Past*, edited by M. Sears and D. Merriman, is the proceedings of the Third International Congress, held September 22–26 (the first congress was held in 1966; the second in 1972); and *Oceanography: The Present and Future*, edited by P. Brewer, is the proceedings of the symposium, held September 29 to October 2, celebrating the founding of WHOI.

I am particularly impressed by *Oceanography: The Past*, which brings to the reader a whole array of little known facts, impressions, and glimpses of the past. The attempts of oceanographers to keep up with the new scientific literature and the science classics limits their reading of oceanography history. This book effectively introduces oceanographers to history and, I hope, whets appetites for further reading of more in-depth accounts, which are included in the various reference lists for each article.

There are 89 articles in *Oceanography: The Past*, most of which are quite short (10 or fewer pages), grouped in no particular order. They deal with a very broad array of topics. Some trace the founding of oceanographic laboratories. WHOI is discussed within many articles; those by Fye; Revelle; Schlee; and Haedrich and Emery were particularly enlightening. Some labs, such as Tortugas Marine Laboratory (Collin's article), have not survived to the present. Some articles deal with instrument development; Hendershott's The Role of Instruments in the Development of Physical Oceanography and Spiess's Some Origins and Perspectives in Deep-Ocean Instrumentation Development are quite good. Others deal with conceptual development (Konvitz's Changing Concepts of the Sea, 1550–1950: An Urban Perspective). The articles by Herman and Platt on the co-evolution of concepts and instrumentation in plankton sampling are particularly effective. Others deal with more obscure topics, such as The Victorian Aquarium in Ecological and Social Perspective by Rehbock and Traditional Chinese Ichthyology and Its Encounter With Jesuit Science: An Historical Survey by Crown. Many present the development of ocean science within various countries (Peru, India, Switzerland, Poland, among others) or the contribution of individuals (such as Agassiz, Vaughan, and Smith).

The style of the articles is uneven, varying from clearly historical topics to attempts at reviewing a discipline. A chapter is devoted to the Six Thermometer, rendered obsolete by the deep-sea reversing thermometer, now also an endangered species. A chapter about salinity might have been interesting.

Oceanography: The Present and Future includes 22 articles grouped in four sections: Small and Local Scale Oceanography; Regional Scale Oceanography; Global Scale Oceanography; and The Human Scale. The scope of each of the first three sections is obvious. The fourth section covers topics of direct concern to society: fate of fossil-fuel CO_2 (Bolin, Changing Global Biogeochemistry); generation of energy from the ocean (Lavi, Innovative Ocean Energy Systems: Prospects and Problems); the possibilities of ocean farming (Gordin, Aquaculture); the importance of good linkage between science development and development of technology (Baker, Technology and Communications: New Devices and Concepts for Ocean Measurement); and a brief discussion of Institutional and Educational Challenges by Steele.

However, other human-scale issues are included in the other sections, e.g., Murphy's The Ocean Nearly: Environmental Problems and Public Policy in the Next Fifty Years and Berman's The Impact of Oceanography on the Military and Security Uses of the Ocean. Pilkey's Shoreline Research might also qualify for the human scale.

The articles are not exhaustive reviews but personal reflections of where we stand and where we're going, by people actively engaged in research. Their views are valuable, and the book makes for interesting reading. I find Harbison's The Structure of Planktonic Communities most interesting: He does a nice job of presenting the difficulties in obtaining unambiguous plankton community data. He says, "The time has come to try to live and work in the open ocean" so that "Those of us interested in plankton ecology" can more closely "become like these 19th century naturalists."

Turner and Garrett do admirable jobs in their articles on Fine and Microscale Ocean Structures and on Coastal Dynamics, respectively. Turner points out how the measurement of temperature and salinity continuously with depth altered our views of the vertical profile; one wonders if similar horizontal resolutions across fronts might have a similar impact. In Garrett's article, I particularly like his five levels of answers to questions pertaining to physical oceanographic processes; we generally are not yet at the highest conclusive theoretical level.

Walter Munk's treatment of Acoustics and Ocean Dynamics gives a good historical account that leads to the potential of ocean acoustic tomography. He ends with two proposals: first, that someone who participated in the development of underwater sound technology should give a firsthand account of this era before it is too late; second, that we need a civilian acoustic array to serve as an observatory for ocean studies.

Childress' Oceanic Biology: Lost in Space) tells of the loneliness of the abyssal creatures; he even ends with a poem, a rare event in oceanographic literature.

I find Rossby's article on Eddies and the General Circulation and Niiler's General Circulation of the Ocean most in line with traditional comprehensive review articles.

Oceanography: The Present and Future makes a nice companion to *Oceanography: The Past*. We all look forward to the WHOI centennial celebration.

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Classified

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POSITIONS AVAILABLE

University of Iowa/Faculty Positions. The Department of Physics and Astronomy anticipates two openings for tenure-track assistant professors or visiting faculty at any level in August 1984. In exceptional cases a term or tenured appointment at the associate professor or professor level will be considered. Preference for one position will be given to an experimentalist in intermediate or high energy physics. Current research interests in the department are radio and optical astronomy and the following specialties in physics: atomic, condensed matter, elementary particle, laser, nuclear, plasma, and space physics. Faculty duties include undergraduate and graduate teaching, guidance of research students and personal research. Interested persons should submit a resume and a statement of research interests and arrange for three letters of recommendation to be sent to Search Committee, Department of Physics and Astronomy, The University of Iowa, Iowa City, IA 52242.

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University of Washington/Postdoctoral Position. Research Associate (postdoctoral) with background in physical oceanography and atmospheric science and interests in dynamical aspects of climate variability. Term of appointment: one (1) year, renewable for a second year subject to the approval of the Council. Closing date: February 1, 1984. Send curriculum vitae and a list of four (4) references to Director, JISAO, c/o Department of Atmospheric Sciences, AK-40, University of Washington, Seattle, WA 98195.

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Texas A&M University/Geological Oceanography Positions. The Ocean Drilling Project (ODP) invites application for the following anticipated positions: Several full-time staff scientist (Ph.D. required). These openings, in various fields of marine geoscience, are anticipated to be filled over a one year period commencing 1 October 1983. The successful candidates will be expected to participate approximately two months per year aboard a scientific drillship. These individuals will be responsible for coordinating activities prior and subsequent to the cruises, including the publication of results. The successful candidates will be expected to attend the JOIDES panel meetings relating to their scientific expertise. Several full-time marine technicians. Previous shipboard experience and undergraduate degree in geology or related science highly desirable. These positions require participation of about 6 months per year (alternating two months on and two months off) aboard a scientific drillship charter.

Applicants should submit a letter of application, curriculum vitae and names of 3 references to: Dr. Philip D. Rabinowitz, Project Director, ODP, Dept. of Oceanography, Texas A&M University, College Station, TX 77843.

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Mineralogist/Petrologist/Geochemist—South Dakota School of Mines. A position as Research Scientist I (research equivalent of assistant professor) is currently available in the Institute for the Study of Mineral Deposits (ISMD) at the South Dakota School of Mines and Technology, Rapid City, South Dakota. A Ph.D. degree in the general areas of mineralogy, petrology, geochemistry is required and the Ph.D. degree must be in hand before assuming a position with ISMD. The successful applicant will interact with the several research programs conducted by ISMD with special emphasis on the mineral deposits of the Black Hills, South Dakota. Major research responsibility will concern a long-term, in-depth study of stratiform gold deposits in the Black Hills. ISMD has a fully automated (WDS + EDS) microprobe and a new state of the art automated atomic absorption spectrometer with inductively coupled plasma torch (AA/ICP) for major, minor and trace element analysis. Arrangements are in place for neutron activation analysis (Battelle, Richland, Washington) and light stable isotope analysis (U.S.G.S.).

Candidates for the position should send resumes and three letters of recommendation to:

J.J. Papike, Director, ISMD
South Dakota School of Mines and Technology
500 East St. Joseph Street
Rapid City, South Dakota 57701–3995

For additional information, call (605) 394-6152. SDSM&T is an affirmative-action/equal opportunity employer.

University of South Carolina/Tenure-Track Positions in Geology. The Department of Geology invites applications for two anticipated tenure-track positions in two of the following areas: 1) Geophysics 2) Igneous Petrology/Structure; 3) Coastal Processes; or 4) Organic Sediments. It is anticipated that the appointments will be at the assistant professor level, but applications from more senior persons will also be given strong consideration. A Ph.D. degree is required. Starting date will be August, 1984, with an application deadline of 1 March 1984. Applicants should send curriculum vitae, statement of research interests, pertinent reprints, and the names of three references to: Dr. Björn Kjerfve, Department of Geology, University of South Carolina, Columbia, SC 29208 (Phone 803-777-4520).

The University of South Carolina is an Equal Opportunity Employer which encourages applicants from qualified minority groups and women.

SUNY-Albany/Tenure-Track Position in Tectonics or Structural Geology. The Department of Geological Sciences at the State University of New York at Albany invites applications for a tenure track position in TECTONICS or STRUCTURAL GEOLOGY starting Fall, 1984. We welcome applicants with interests and experience in tectonic processes, including geophysical and structural approaches to structural geology, including physical properties of earth materials or structural aspects of metamorphic processes; or similar fields which complement our existing strengths. Preference will be given to individuals whose research combines quantitative and field studies. The position will be filled at the Associate or Assistant Professor level. Inquiries or applications should be addressed to Dr. W.D. Means, Department of Geological Sciences, State University of New York at Albany, 1400 Washington Avenue, Albany, New York 12222. Application deadline is February 15, 1984.

SUNY-Albany is an equal opportunity/affirmative action employer. Applications from women, minorities, handicapped and Viet Nam era veterans are especially welcome.

Post-Doctoral Position/Naval Postgraduate School. The Ocean Turbulence Laboratory has available a post-doctoral position for a person interested in the analysis and interpretation of oceanic turbulence data. The tenure is for 1 or 2 years. The successful candidate should have a Ph.D. in physical oceanography and although experience with turbulence theory is preferrable it is not essential. The opportunity for involvement in data gathering expeditions is also available.

Resumes can be sent to Dr. R. G. Lueck, Code 68Ly, Naval Postgraduate School, Monterey, CA 93943.

The Naval Postgraduate School is an Equal Opportunity/Affirmative Action Employer.

Geophysicist, Tectonophysicist/Georgia Tech. The School of Geophysical Sciences at Georgia Tech invites applications for a faculty appointment in Earth Sciences. Applicants must have an outstanding research potential demonstrated by several years of postdoctoral experience or a well-established research record, and experience in securing research funding. Although no field of specialization is excluded, preference will be given to candidates with a background in geophysics/tectonophysics.

The School of Geophysical Sciences has an expanding and active research program in many areas of Earth and Atmospheric Sciences. The School has 23 full-time faculty members and over 50 graduate students.

Applications including resumes, phone numbers, and the names and addresses of at least three references should be submitted to Jean-Claude Marechal, Chairman, Geophysics Search Committee, School of Geophysical Sciences, Georgia Institute of Technology, Atlanta, GA 30332.

The Georgia Institute of Technology is a unit of the university system of the State of Georgia.

Georgia Tech is an affirmative action/equal opportunity employer.

Scientist I and II/National Center for Atmospheric Research. Candidate should have strong interest and publication record in tropospheric chemistry. Ph.D. in chemistry or meteorology and skill with FORTRAN. Research in modeling and theory is anticipated with appointment at Scientist I and II in NCAR's Atmospheric Chemistry and Aeronomy Division. Scientist I and II appointments are for terms of up to three and four years, respectively. Individuals may be appointed to the next higher level of scientist in accordance with UCAR Scientific Appointments Policy. Apply with resume to National Center for Atmospheric Research, ATTN: Margareta Domecki, P. O. Box 3000, Boulder, Colorado 80307 by December 30, 1983.

Equal Opportunity Employer M/F.

Faculty Opening/Department of Geological Sciences, Rutgers University, Newark. Tenure-track Assistant Professorship with research and teaching interest at both the undergraduate and graduate levels in Hydrogeology or Geophysics. The appointee will also be required to teach Structural Geology at the undergraduate level. Ph.D. required, publication record and/or experience desirable. Position available July 1, 1984. Salary commensurate with qualifications and experience.

Applicants should submit a resume, names of three references and a statement of research interest by March 31, 1984, to:

Dr. Andreas H. Vassiliou, Chairman
Department of Geological Sciences
Rutgers University
Newark, New Jersey 07102

Rutgers University is an Equal Opportunity/Affirmative Action Employer.

University of Arizona/Postdoctoral Research Position in Planetary Atmospheres. Applications are invited for postdoctoral research positions at the Lunar and Planetary Laboratory, University of Arizona, in Tucson, Arizona. The two positions will involve research in planetary physics and analysis of UV data from the Voyager mission. Research opportunities for these positions include the bound and extended atmospheres and ionospheres of the giant planets and their satellites, the Io plasma torus, earth's atmospheres, the interstellar medium, and the atmosphere and ionosphere of Venus. Applicants should have a strong background in theory and data analysis. Physicists and astronomers are encouraged to apply. Curriculum Vitae, bibliography and three letters of reference should be sent by March 1, 1984 to Dr. A. L. Broadfoot, Lunar and Planetary Laboratory, University of Arizona, 3625 E. Ajo Way, Tucson, Arizona 85713

The University of Arizona is an Equal Opportunity Employer.

EOS

Transactions, American Geophysical Union

The Weekly Newspaper of Geophysics

For speediest treatment of contributions send three copies of the double-spaced manuscript to one of the editors named below and one copy to AGU.

Editor-in-Chief: A. F. Spilhaus, Jr.; **Editors:** Marcel Ackerman, Mary P. Anderson, Peter M. Bell (News), Bruce Doe, C. Stewart Gillmor (History), Clyde C. Goad, Arnold L. Gordon, Louis J. Lanzerotti, Robert A. Phinney; **Managing Editor:** Gregg Forte; **News Writer:** Barbara T. Richman; **News Assistant:** Tony Reichhardt; **Production Staff:** James M. Hebblethwaite, Dae Sung Kim, Patricia Lichiello, Lisa Lichtenstein, Cynthia T. McManigal.

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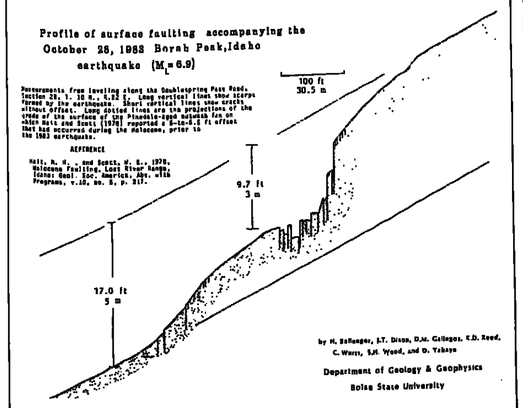
Cover: Borah Peak, Idaho, Earthquake, October 28, 1983



Cover photos, reading clockwise from top left:

Looking southwest and down from a helicopter at a group of sand boils associated with the earthquake. Approximate diameter of pools is 12–18 m. Photo taken about 8 hours after the earthquake. Pools located about 0.4 km north of the north edge of the Chilly Buttes in the Thousand Springs Valley. The quake produced a 40-km-long fault scarp with a normal vertical offset up to approximately 5 m running northwest-southeast along the west side of the Lost River Range, about 6 km east of the Chilly Buttes. (Photo and information courtesy of Jack Pelton, Boise State University.)

Looking east across the surface faulting on the Doublespring Pass Road. Total offset on fault is 3 m at this point. Main rupture zone shown here is about 60 m wide, but smaller scarps and cracks occur over a total width of about 90 m. (Photo by Nick Ballenger; information courtesy of Spencer H. Wood, Boise State University.)

Looking northeast toward the normal fault scarp produced in the vicinity of Arentson Gulch. This surface break was actually witnessed by two elk hunters, D. Hendricksen and J. Turner of Boise, as they drove northeastward along the rutted dirt road on the downthrown block in the foreground. Photo taken approximately 30 minutes after the earthquake from the position of the right front tire at the time of the surface break. The vertical offset across the road is about 1.8 m. (Photo by D. Hendricksen; information courtesy of Jack Pelton.)

Looking south and down from a helicopter at a pair of muddy-water eruptions. The hillside openings are about 6 m in width and issue from the north side of the Chilly Buttes. Other muddy-water eruptions issued from the east side of the Chilly Buttes. Photo taken approximately 8 hours after the earthquake. (Photo and information courtesy of Jack Pelton.)

Faculty Positions/SUNY Stony Brook. The Department of Earth and Space Sciences, invites applications for a tenure-track faculty appointment. Rank and salary will be dependent on qualifications. The succesful applicant must have research experience and an interest in teaching graduate and undergraduate students. Area of specialization are open since we are looking primarily for high-caliber applicants, but preference will be given to applicants with research interests in the areas of sedimentary geology and fluid-rock interactions which complement those of the existing program.

Qualified persons should send a resume with the names of three references to: Prof. William L. Meyers, Dept. of Earth and Space Sciences, SUNY Stony Brook, Stony Brook, NY 11794.

SUNY Stony Brook is an equal opportunity/affirmative action employer. AK643B.

Microprobe Technician/South Dakota School of Mines and Technology. Applications are invited for a position as microprobe technician for the Institute for the Study of Mineral Deposits. The microprobe is an ETEC (MAC-5) with 5 spectrometers with Kristel automation and a quantitative PGT energy dispersive system. The successful applicant will be responsible for the day-to-day operation of the instrument including maintenance and repair of hardware, development of software, routine analysis of minerals, and assistance to students. A background in electronics is required. Salary commensurate with experience and qualifications.

Applicants should send a resume and three letters of recommendation to J.J. Papike, Director, Institute for the Study of Mineral Deposits, South Dakota School of Mines and Technology, Rapid City, South Dakota 57701–3995. Closing date: March 31, 1984. For additional information, call (605) 394-6152.

SDSM&T is an affirmative-action/equal opportunity employer.

University of Washington/Faculty Position in Geophysics. The Geophysics Program at the University of Washington invites applications for a tenure track position. The successful candidate will be expected to teach courses at the senior and graduate student level and to establish innovative, forward-looking research programs. Application with a Ph.D. and evidence of outstanding potential in basic research in any subfield of solid-earth geophysics will be considered. However, applicants with prime interest in studying global seismology or in studying the physical properties of the earth's mantle and core will receive preference. Curriculum vitae and four letters of reference should be sent prior to 31 January 1984 to:

Professor Ronald T. Merrill
Chairman, Recruitment Committee
Geophysics Program AK-50
University of Washington
Seattle, Washington
Seattle, WA 98195

The University of Washington is an affirmative action/equal opportunity employer.

Louisiana State University/Electronic Design Engineer. Anticipated opening for electronic design engineer with experience in design and fabrication of microprocessor-based oceanographic data recording systems. Appointment for nine months to be extended if funds are available. Contact Dr. Charles Adams, Jr., Louisiana State University, Coastal Studies Institute, Baton Rouge, Louisiana, 70803, (504) 388-5925. Applications must be received by January 10, 1984.

LSU is an Equal Opportunity Employer.

Seismologist/Virginia Polytechnic Institute and State University. The Department of Geological Sciences at Virginia Tech invites applications for an additional tenure-track faculty appointment, at the junior level, in Reflection Seismology. Research facilities include a complete VIBROSEIS 48-channel seismic data acquisition system and a dedicated VAX 22/780 computer using DIGICON DISCO software.

Applicants must demonstrate a strong research record; preference will be given to those with experience in the theoretical and observational aspects of reflection seismology. Faculty members are expected to teach at both the undergraduate and graduate levels, supervise M.S. and Ph.D. theses, and conduct an active research program.

Applicants should send a resume and the names and addresses of three referees to:

J. A. Snoke
Department of Geological Sciences
Virginia Tech
Blacksburg, VA 24061

The appointment will begin September 1984 and candidates are expected to have completed requirements for the Ph.D. by that time. The application deadline is March 15, 1984.

Virginia Tech is an equal opportunity/affirmative action employer.

New Zealand Oceanographic Institute/Physical Oceanographer. A vacancy exists in Wellington, New Zealand, at the New Zealand Oceanographic Institute (Division of Marine and Freshwater Science) for a physical oceanographer to study dynamic processes on the continental shelf. Applicants should have a Ph.D. with 1–2 years post-doctoral (or equivalent) experience. A broad knowledge of physical oceanography is required, preferably including specific expertise in coastal exchange processes.

Salary up to NZ$30,127 per annum dependent upon qualifications and experience.

DMFS is a division of the Department of Scientific and Industrial research having a staff of 56 engaged in marine physical geological and biological research based in a new laboratory in Wellington and 18 at the Freshwater Laboratory at Taupo. Present facilities include a 1000 tonnes research vessel, a comprehensive oceanographic library and a multi-user minicomputer linked to a network of VAX-11/780 computer with access to an IBM 3033 mainframe system.

Further information, application forms, etc., may be obtained from: The New Zealand Embassy, Washington, DC.

Applicants should quote vacancy number 6109 and forward applications accompanied by a resume to:

The Ambassador
New Zealand Embassy
Observatory Circle, NW
Washington, DC 20008

Applications must be received at the above address by February 24, 1984.

Jet Propulsion Laboratory/Physical Oceanography. An opportunity is available in the Oceanography Group at the Jet Propulsion Laboratory, California Institute of Technology, for an individual with a BS or MS degree in oceanography, ocean engineering, or related field. Demonstrated ability in computer programming is required. Will participate in research projects on ocean circulation and tides involving the use of satellite altimetric data and ship-board hydrographic data. Please submit resume by January 15, 1984, to Professional Staffing, Department 101, Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA 91109.

An equal opportunity employer

Geophysics-Tectonophysics/University of Wyoming. Applications are invited for a tenure track position at the Assistant Professor level in the Department of Geology and Geophysics. Candidates should have teaching and research interests in such areas as tectonophysics, thermal modeling and/or plate tectonics. The successful applicant will join an established Ph.D. level geophysics program. Duties will include teaching undergraduate and graduate level geophysics courses, and establishing a vigorous research program. Excellent opportunities exist for cooperation with mathematics; the Mathematic Department includes a strong numerical methods group with interests in geophysics. Send resume, transcripts and three letters of recommendation by January 15, 1984 to Peter N. Shive, Dept. of Geology/Geophysics, PO Box 3006, University of Wyoming, Laramie, WY 82071.

The University of Wyoming is an equal opportunity/affirmative action employer.

Geophysicist or Tectonophysicist/University of Kansas. KU seeks applications for a tenure-track faculty position in geophysics. Candidates should have research interests in crustal geophysics. The successful applicant will be expected to teach undergraduate and graduate geophysics courses, develop an active research program, advise students, supervise graduate student theses and dissertations, and provide service through administrative and professional activities. A Ph.D. in geology with specialization in geophysics is required although applicants who will complete the Ph.D. within the first year of employment at KU will be considered. The position is at the assistant professor level with a salary commensurate with qualifications. The starting date is August 16, 1984 and the application deadline is February 1, 1984. Send vita, transcripts, a brief statement of research interests and courses the applicant feels qualified to teach, and three letters of reference to G. H. Girty, Department of Geology, University of Kansas, Lawrence, Kansas 66045. The advertised position is contingent on continued state funding. For additional information contact G. H. Girty or phone (913) 864-4974.

KU is an affirmative-actions, equal-opportunity employer. Applications are sought from all qualified people regardless of race, religion, color, sex, disability, veteran status, national origin, age, or ancestry.

Global Weather Dynamics, Inc/Computer Specialist. Location: National Meteorological, and Environmental Center (NMEC) within the Meteorological and Environmental Protection Administration (MEPA), Jeddah, Kingdom of Saudi Arabia.

Academic Qualifications: Master of Science preferred with major in Meteorology and/or Computer Science. Appropriate types and duration of experience may be acceptable in lieu of academic qualifications.

Experience: Extensive computer experience including responsibility for data base design, development and implementation together with experience in data base management preferably using Control Data Corporation (CDC) computer systems. Experience in writing requirements documents and demonstrated advanced COBOL and FORTRAN programming skills are essential. Experience in file handling applications having professional experience with CDC operating systems and file management. Experience in Meteorology including data quality control and familiarity with archiving procedures in a major meteorological and/or climatological center desirable. Evidence of a broad interest in the environmental sciences would be an additional advantage.

Duties: The appointee will report to the Assistant Director of Climatology, MEPA. He will have primary responsibility for the design, development and implementation of the digital climatological and environmental data base. He will be responsible for training a Saudi counterpart in data base maintenance. He will also be required to liaise effectively with the Data Base Meteorologist, Quality Control Meteorologist and Environmental Specialists in the course of carrying out the Data Base Development Program and with the computer center staff in day-to-day operations.

Send resumes to:

Global Weather Dynamics, Inc.
2400 Garden Road
Monterey, California 93940
Attention: Louise Gates
Telephone: (408) 649-4500

Global Weather Dynamics, Inc. is an Equal Opportunity/Affirmative Action Employer.

Massachusetts Institute of Technology/Faculty Position. The Department of Earth, Atmospheric, and Planetary Sciences at M.I.T. seeks applicant for an appointment in the area of experimental atmospheric chemistry at the tenured full professor level. We seek an individual who is widely recognized as one of the world's leaders in experimental atmospheric chemistry and who has a broad intellectual interest in global environmental issues. The applicant should possess specific expertise in atmospheric (or atmospheric and oceanic) trace gas and isotopic measurements.

Interested individuals should send a copy of their curriculum vitae and names of three references to:

William F. Brace, Chairman
Dept. of Earth, Atmospheric
and Planetary Sciences
54-918
M.I.T.
Cambridge, MA 02139

M.I.T. is an Affirmative Action/Equal Opportunity Employer.

University of California/Faculty Appointments. The Department of Geology and Geophysics at the University of California, Berkeley, CA. 94720, pending budgetary approval, expects to make two faculty appointments effective Fall 1984, one at the junior level and one at the senior level. Applicants must be interested in pursuing a vigorous research program and in teaching both undergraduate and graduate students. The preferred areas of specialization are sedimentary petrology and sedimentology, stratigraphy and petroleum geology, regional tectonics, geochemistry, economic geology, and metamorphic geology. Applications, including the names of references, should be sent to the Chairman at the above address by January 15, 1984.

The University of California is an Equal Opportunity/Affirmative Action Employer.

University of Washington/Paleontology/Paleobiology, Geochemistry. The Department of Geological Sciences invites applications in the areas of paleontology/paleobiology and geochemistry (especially economic or isotope geochemistry). We are interested in candidates who will establish exceptional and innovative research programs. Postdoctoral research experience is highly desirable. One opening is available beginning September 1984. This is a tenure-track position at the rank of Assistant Professor or higher under exceptional circumstances. A second position may be available in September 1985. A paleontologist/paleobiologist may seek a joint appointment with the Burke Museum on campus. A successful candidate in either area will be expected to teach at both the undergraduate and graduate levels.

Applicants should send vitae and names of four references to John B. Adams, Chairman, Department of Geological Sciences, AJ-20, University of Washington, Seaule, Washington 98195. Closing date for applications is February 15, 1984.

The University of Washington is an Affirmative Action/Equal Opportunity Employer.

Atmospheric Scientist/Radiophysicist—M.I.T. A scientist is required to join the staff of the Haystack Observatory, (operated by M.I.T. on behalf of the Northeast Radio Observatory Corporation) to conduct a program of experimental investigation into the dynamics of the troposphere and stratosphere. The work will be carried out at the adjacent Millstone Hill facility using a 150 ft. diameter steerable radar which can secure returns from clear air turbulence. The successful candidate will be expected to have a Ph.D. degree obtained for research conducted in a related field, and a demonstrated ability to carry out an experimental program entailing data acquisition, analysis and theoretical interpretation. Several years experience using high-power radar for research or conducting other experimental investigations into atmospheric dynamics would be particularly valuable. Contact Dr. J.V. Evans, Director, Haystack Observatory, Westford, Mass., with resumes and references.

M.I.T. is an Equal Opportunity/Affirmative Action Employer.

Jet Propulsion Laboratory Computing Analyst/Oceanographer. An opportunity is available in the Oceanography Group at the Jet Propulsion Laboratory, California Institute of Technology. The position requires a Bachelor's degree in Computer Science or related field. Experience in VAX/VMS programming is essential including knowledge of FORTRAN, RATFOR and C. Familiarity with image processing and remote sensing is desirable. The position will involve development and maintenance of an image processing system which will be used for analysis of satellite imagery. Please submit resume to Professional Staffing, Department 182, Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA 91109.

An equal opportunity employer M/F.

The College of William and Mary/Physics Faculty Position. William and Mary expects to have a tenure-track opening at the assistant-professor level for August, 1984. Preference will be given to applicants in the fields of theoretical plasma physics including computer simulation), nonlinear mechanics, or statistical mechanics. The physics department currently consists of 22 faculty, 7 postdoctoral research associates, and 40 Ph.D. candidate graduate students. Plasma physics funding is currently from NASA and the Department of Energy. Please send vitae and list of three references to: Chairman, Search Committee, Physics Department, College of William and Mary, Williamsburg, Virginia 23185.

William and Mary is an affirmative-action, equal-opportunity employer; women and minority applicants are encouraged to apply.

Naval Postgraduate School, Faculty Positions/Meteorology. The Department of Meteorology, Naval Postgraduate School, invites applications for a tenure-track and a non-tenure track position at the Assistant or Associate Professor level. The positions are for persons whose teaching and research interests are in the fields of remote sensing and synoptic meteorology. The successful applicants will teach graduate and undergraduate courses and will be expected to develop an active research program that complements his/her teaching. Rank and salary will be commensurate with the experience and qualifications of the successful applicants. Send a resume, names and addresses of three references, and a statement of academic and research interests, including availability for a non-tenured position, by 31 Dec 1983 to: Professor R. J. Renard, Chairman, Department of Meteorology, Naval Postgraduate School, Monterey, California 93943. (Area code 408-646-2518/?).

The Naval Postgraduate School is an equal opportunity employer.

The Johns Hopkins University/Tenure-track Assistant Professor Position. The Department of Earth and Planetary Sciences invites application for a tenure-track position at the Assistant Professor level beginning July 1, 1984, in paleobiology, regional tectonics, economic geology, or isotope geology. Ph.D. required. Send resume and names of three references to Lawrence A. Hardie, Department of Earth and Planetary Sciences, The Johns Hopkins University, Baltimore, MD 21218, U.S.A.

Johns Hopkins is an equal opportunity/affirmative action employer.

Atmospheric Sciences Research Center/Staff Member. A position up to a three-year term appointment is available at the Atmospheric Sciences Research Center.

The ASRC seeks a staff member whose research interests are in the application of boundary layer or mesoscale meteorology to cloud and fog processes. The successful applicant must have a Ph.D. and must have a proven potential as a researcher, i.e., publications and successful research grant(s).

Send resume to:

Dr. G. Garland Lala
ASRC—Earth Science 324
State University of New York at Albany
1400 Washington Avenue
Albany, New York 12222

An Equal Opportunity Employer.

University of Georgia/12-month tenure-track faculty appointment in the School of Forest Resources. Qualifications: Ph.D in hydrology or forest hydrology with at least one degree in forest resources. Background should include forest resource management and quantitative sciences. Responsibilities: Teach undergraduate and graduate level courses in forest hydrology and watershed management. Develop a research program in an appropriate area of forest hydrology. Rank: Assistant or Associate Professor, commensurate with qualifications. Salary: Commensurate with training and experience. Position available: July, 1984. Applications: All applications must be postmarked no later than 1 February 1984. Submit resume, transcripts, and names of at least three references to:

Klaus Steinbeck, Chairman
Hydrologist Search Committee
School of Forest Resources
University of Georgia
Athens, GA 30602
Telephone 404-542-1376

The University of Georgia is an Equal Opportunity/Affirmative Action Institution.

Microprobe Technician-Operator/University of Maine at Orono. Subject to budgetary approval, the Department of Geological Sciences at UMO will have this position available by February 1, 1984. Person appointed must be capable of bringing an automated MAC 400S probe on line as a routine instrument; also able to instruct students on its operation. Similar capabilities with a mass spectrometer highly desirable. Some geologic background preferred. Initial appointment for one year with likelihood of subsequent reappointment. Salary in the range of $17,000–$20,000/year. Apply to: G.V. Gadoleti, Department of Geological Sciences, University of Maine at Orono, Orono, Maine 04469.

The University of Maine is an equal opportunity/affirmative action employer.

Faculty Position/Northwestern University. Professor Geological Sciences. Duties include teaching introductory and advanced courses in Geology, Geochemistry, Petrology, and Mineralogy; research in experimental petrology; graduate student advising; recruitment and other administrative duties. Earned doctorate in Geological Sciences, postdoctoral study and minimum 3 to 5 years experience required. Extensive knowledge of high pressure experimental research and the application of chemical thermodynamics to geology essential. 9 month salary $34,000. Applicants must submit c.v. by January 15, 1984 to:

Seymour O. Schlanger, Chairman
Department of Geological Sciences
Northwestern University
Evanston, IL 60201

Northwestern University is an equal opportunity/affirmative action employer.

Faculty Position in Geology/Hunter College. New York, N.Y. Hunter College, City University of New York. Fall 1984. Rank and salary open. Position for an advanced or starting scientist to take an aggressive role in an expanding research program emphasizing geologic applications of remote sensing, mathematical modeling, statistical data analysis, and related quantitative areas. Research emphasis in geophysics or hydrogeology will be helpful, but not required. Proven extramural funding ability is required for advanced level appointment. Experience with government, industry and foreign nations also helpful. Ph.D. required at time of appointment. Send vitae, publications, names of at least three referees to Dr. Alan H. Strahler, Hunter College, Dept. of Geology and Geography, 695 Park Avenue, New York, N.Y. 10021. Closing date March 1, 1984

Equal Opportunity Employer.

Minnesota Pollution Control Academy/Hydrologist. Applications are being accepted for a hydrologist position with the Minnesota Pollution Control Agency. The vacancy is in the metropolitan Minneapolis/St. Paul area. Applicants must have a background in geology, hydrology or engineering with specific coursework and/or experience in ground water hydrology. A Master's degree may be substituted for a portion of the experience rating. Experience in using and evaluating ground water models is desired. The position will include limited field work and contractor supervision. For application information please contact:

Richard Nelson
Minnesota Pollution Control Agency
1935 West County Road B-2
Roseville, Minnesota 55113
Telephone: (612) 296-7761

The State of Minnesota is an equal opportunity employer.

The Johns Hopkins University/Postdoctoral Fellowship in Structural Geology. The Department of Earth and Planetary Sciences seeks a quantitative structural geologist to fill a one-year postdoctoral fellowship (renewable). Ph.D. required. Send resume and three reference letters, by January 31, 1984, to: Dr. Don G. DePaor, Earth & Planetary Sciences, Johns Hopkins University, Baltimore, Maryland 21218.

The Johns Hopkins University is an equal opportunity/affirmative action employer.

STUDENT OPPORTUNITIES

Opportunities for Graduate Studies in Atmospheric Sciences/Georgia Institute of Technology. Openings are available for outstanding individuals seeking an M.S. or Ph.D. degree in graduate studies in atmospheric sciences. For successful applicants, these positions include 1/2-time research assistantships with starting salaries ranging from $9,000 to $12,500/12 months, depending on the degree being sought and the student's qualifications. All tuition and fees are also covered by the Institute. Complete applications with supporting documentation should be received no later than March 15, 1984.

Interested students should write to:

Dr. Douglas B. Davis
School of Geophysical Sciences
Georgia Institute of Technology
Atlanta, GA 30332.

TWO SHORT COURSES
at
Colorado State University

COMPUTER MODELING FOR WATER SHED HYDROLOGY, June 4–8, 1984. Course Director: J. D. Salas. Fee: $600.00.

EROSION AND RIVER BEHAVIOR ANALYSIS, June 25–29, 1984. Course Director: H. W. Shen. Fee: $600.00.

FOR INFORMATION or to receive a brochure describing the course in detail: Hydrology and Water Resources Program, Engineering Research Center, Colorado State University, Fort Collins, Colorado 80523. (303) 491-8552.

Meetings

Announcements

Aeration Zones

A call for papers has been issued for the International Symposium on Recent Investigations in the Zone of Aeration (RIZA), to be held October 1–5, 1984, in Munich, West Germany. The symposium will underscore the importance of interdisciplinary communication between the fields of agriculture, biogeochemistry, ecology, geochemistry, geology, hydrochemistry, hydrology, isotope hydrology, microbiology, soil sciences, and water resources in the research of the unsaturated zone.

Among the topics planned for the meeting are new research methods, transport and phase interaction, effects of land use, and modeling. Also planned are workshops on measuring techniques and applications of microcomputers and several field trips.

Scientists wishing to present a paper should submit a one-page summary in English no later than January 31, 1984, to P. Udluft, RIZA Symposium, Institut für Wasserchemie der TU München, Marchioninistr. 17, D-8000 Munich 70, West Germany. The symposium is sponsored by the department of hydrogeology and hydrochemistry of the Technical University of Munich under the patronage of K. E. Quentin.

Seismic Deconvolution

The Society of Exploration Geophysicists (SEG) Research Committee is organizing a workshop on seismic deconvolution in Vail, Colo., July 17–20, 1984. Among the topics to be featured are multiple attenuation, practical deconvolution, model validation, wavelet estimation and removal, and quantitative measures of success.

The program will include invited presentations and contributed poster papers. Primary emphasis will be on real data cases. Those wishing to present poster papers should send an abstract to Sven Treitel, Amoco Production Co. Research Center, P.O. Box 591, Tulsa, OK 74102; the deadline is March 15, 1984.

Mars Workshop

"The Case for Mars II," a workshop to appraise the future of manned missions to Mars, will be held in Boulder, Colo., July 10–14, 1984. Following in the footsteps of the 1981 "Case for Mars Conference," the workshop aims to provide a continuing forum and contact point for those interested in manned Mars missions and colonization of Mars.

Potential topics include unmanned precursor missions to Mars; earth-to-Mars transit options; Mars landing and departure systems; in-flight life support systems; Martian surface activities; social and political aspects of Mars colonization; and use of Martian resources.

For preregistration details about the workshop, contact Helen Hatt, Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, CO 80309 (telephone: 303-492-8822) or Carol Stoker and Tom Meyer, Case for Mars, P.O. Box 4877, Boulder, CO 80306 (telephone: 303-494-4144).

May 15, 1984, is the deadline for submitting titles of papers for presentation at the meeting; abstracts and preregistration forms are due June 1. Registration will be limited to 150 persons.

For additional information on the Mars Initiative of the Planetary Society, sponsor of the workshop and of university courses on topics related to Mars colonization, write to Mars Institute, Planetary Society, 110 S. Euclid Ave., Pasadena, CA 91101. Do not write the institute for workshop information.

EGS Meeting

A call for papers has been issued for the 10th European Geophysical Society (EGS) Annual Meeting, to be held July 30–August 3, 1984, in Louvain-la-Neuve, Belgium. Some of the symposia and workshops organized by the External Geophysics Section (section 3) as part of the meeting may be of interest to AGU members. The deadline for submission of abstracts for all of the sessions listed below is April 15, 1984. Address inquiries to the conveners.

The symposium "Solar Geophysical Indices Revisited" is being convened by L. Bossy, Institut d'Aeronomie Spatiale de Belgique, 3 avenue Circulaire, B1180 Brussels, Belgium, and by F. A. Simon of Meudon, France.

K. Knott is the convenor of the symposium "First Results from European Geophysics and Solar Experiments on Spacelab." Write to Knott at the European Spaceab Agency, Postbu 299, 2200 AG Noordwijk, The Netherlands.

The symposium entitled "Thermosphere/Ionosphere Coupling at High Latitudes and Possible Solar Wind/Magnetosphere Influence" is being convened by D. Rees, Department of Physics and Astronomy, University College, Gower Street, London WC1E 6BT, UK, and by T. Killeen of Ann Arbor, Mich.

"Future Planetary Missions" will be convened by F. M. Neubauer, Institut f. Geophysik und Meteorologie, Universit. zu Koln, Zulpicherstrasse, 49, D 5000 Koln 1, FRG; G. Neukum of Wessling, FRG; and F. W. Taylor of Oxford, UK.

The workshop "Magnetospheric Effects of Seismic Activity" will be convened by F. Lefeuvre, CRPE/CNRS, 3 avenue de la Recherche Scientifique, F 45045 Orléans Cedex, France, and by M. B. Gokhberg of Moscow, USSR.

Meeting Report

Predictability of Mesoscale Phenomena

The Symposium on Predictability of Mesoscale Phenomena (DM3), held at the 1983 IUGG General Assembly, addressed two questions: (1) What mechanisms control the predictability of mesoscale phenomena, in particular quantitative precipitations? (2) Over what time interval can these events be predicted? The papers presented were related more to the first question than to the second. Two sessions were organized. Session 1 was reserved for the meso-α type studies and session 2 for the meso-β type studies. Space does not permit discussion of all contributions.

In Session 1, Zeng Qing-cun and Rongfend Zi (People's Republic of China), using shallow water equations linearized with respect to a steady zonal flow, defined three types of instabilities which may develop disturbances (in the pressure-temperature interacting fields): (1) generalized barotropic instability, (2) inertial (symmetric) instability

Meetings (cont. on p. 990)

Meetings *(cont. from p. 989)*

and (3) "supercritically high speed instability". Kerry A. Emanuel (USA) described a similar symmetric instability for a moist case in terms of Lagrangian parcel dynamics. Emanuel's analysis differs from the classical analysis of convective available potential energy by the fact that the displacement was performed along a surface of constant angular momentum (rather than in the vertical). Case studies of slantwise moist convection show that moist adjustment in the baroclinic atmosphere proceeds in such a way as to drive toward zero the total potential energy (maximized by displacing the parcel along a surface of constant angular momentum).

Another paper (C. A. Nash, UK) suggested that the so-called Conditional Symmetric Instability (CSI) is responsible for the organization of the precipitation of frontal systems in quasi 2-dimensional bands parallel to the front. The author showed that if a numerical simulation of the development of CSI is performed in a fluid with constant shear and static stabilities, the flow evolves into two rolls aligned along the front with opposite senses of circulation. The rolls are separated by an updraft zone. Two papers (L. Dell'Osso of Italy and P. Albert of Israel) were related to orographic forcing.

In session 2, Erik Rasmussen (Denmark) showed that meso-interactions rather than baroclinic instability is the cause of polar-lows development in the Norwegian Sea. Juan Payle and others (USA) suggested that the diurnal cycle (or modulation) of convection intensity often observed over the Great Plains is a result of a topographically induced convergence field and a shallow jet east of the Rocky Mountains. A boundary layer model applicable over complex terrain has simulated such a diurnal oscillation with an acceptable accuracy.

A similar topographically induced phenomenon was described by Tsung-yao Wu and Shi-ting Wang (People's Republic of China). Using Lorenz definition of the first and second kind of meso-α flows predictability, and the fact that disturbances within those flows could be better simulated knowing initial horizontal wind conditions (Doppler radar), Tzvi Gal-Chen and Robert A. Kropfli (USA) tested Gal-Chen's model against boundary layer data. In order to make that technique viable the authors indicated that the radars had to resolve the PBL with at least 15–20 vertical levels. Sun Shuging and Tien Sheng-chun (People's Republic of China) emphasized the role of the low-level jet in the formation of heavy rainfalls in China, namely some wind pulses measured at a mountain meteorological station near the jet-axis. The authors supposed the development of a mesoscale wave with a large amplitude, a few hours period and a speed of 80–100 km h^{-1}.

Isidoro Orlanski and Bruce Ross (USA) presented a 3-dimensional simulation of the evolution of an observed moist cold frontal system emphasizing that on its mature, quasi-steady state the maximum vorticity line as a result of a negative feedback mechanism. This mechanism inhibits further vorticity growth without requiring viscous damping.

W. R. Peltier (Canada) and T. L. Clark (USA), and W. R. Peltier and G. P. Klaussen (USA), using different versions of Clark's 3-D mesoscale model simulated downslope windstorm evolutions and the collapse of finite amplitude Kelvin-Helmholtz 2-D waves (for a Reynolds number $Re > 250$) respectively. The 2-D wave seems to collapse when the Re number falls down from 900 to ≈250. The downslope windstorms were explained by an overturning of the streamlines at some height above ground. The air flowing over topography overturns, inducing a superadiabatic subregion that becomes turbulent. The authors stated that when a level of mean flow reversal is present, the wave over mountains may amplify resonantly but only if the height of the critical level above the ground is three-fourths of a critical vertical wavelength.

I would like to acknowledge the travel assistance provided by National Science Foundation grant ATM-8219473.

This meeting report was prepared by André Doneaud, *who is with the Institute of Atmospheric Sciences, South Dakota School of Mines and Technology, Rapid City, SD 57701-3995.*

Dissolved Loads and Water Quality

The IAHS Symposium on Dissolved Loads of Rivers and Surface Water Quantity/Quality Relationships took place in Hamburg, West Germany, August 16–18, 1983, as part of the IUGG 18th General Assembly. Coconvenors, B. W. Webb of the University of Exeter, UK, and R. A. Gras of Electricité de France, delineated 3 topics: "Spatial and Temporal Variations in Dissolved Loads and Solute Concentrations," "Solute Sources, Budgets, and Denudation," and "Applications of Surface Water Quantity/Quality Relationships".

From the range of field investigations discussed, it was apparent that different perspectives on the symposium title were being affected by scale and academic ideals. That is, intense and detailed studies on smaller watersheds were advocating study approaches radically different from those interested in macroscale (basinwide or global) analyses. The former become imbedded in assessing chemical processes and in formulating causal relationships for observed data. The latter tend to rely on empirical data-analysis techniques.

A wide disparity of opinion was expressed on the forms of concentration-discharge or load-discharge relationships to be applied. A few participants questioned the usefulness of even formulating such relationships. At any rate, participants of this symposium expressed little interest in the cost effectiveness of water-quality data programs or in the need to develop trade-offs between costs and accuracy of desired information. *In the opinion* of this reporter, this *key issue should* take precedence over the somewhat academic but interesting deliberations which pervaded the symposium discussions.

This meeting report was contributed by Timothy D. Steele, *who is with the Engineering and Environmental Science Division of In-Situ, Inc., 7401 W. Mansfield Ave., Lakewood, CO 80235.*

GAP

Separates

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Aeronomy

0430 Composition
STRATOSPHERIC NO_2 AT NIGHT FROM BALLOONS
J.P. Naudet (Laboratoire de Physique et Chimie de l'Environnement, 45000 ORLEANS CEDEX, FRANCE), P. Rigaud and D. Huguenin.

Stratospheric NO_2 was measured at night by means of a balloon-borne spectrometer pointing at a bright rising or setting star in the 440 nm region. Four flights were made from May 1976 to September 1981. For the last flight two vertical profiles of the NO_2 mixing ratio were recorded within a time span of two hours. The two profiles were identical within the error range and the average profile is in good agreement with results of previous flights.

The NO_2 mixing ratio increased from about 6.1 ppb at 26 km to about 13.3 ppb at 35 km. It favourably compares with theoretical predictions above 30 km and with observations of $NO_x = NO + NO_2$ by solar occultation. (Stratosphere, Nitrogen dioxyde).
J. Geophys. Res., Atmos., Paper 3D1851

Electromagnetics

0720 Electromagnetic Theory
CONVECTION AND DIFFUSION MODES OF INDUCED EARTH CURRENT
D. E. Summers (Department of Architecture, University of Edinburgh, Edinburgh, U.K.)

The physical interpretation which Price (1950) attached to the solutions of the pre-Maxwell equations is examined and the validity of linear circuit analogies to the problem of geomagnetic induction is questioned. If induced Earth currents are solely diffusive, then geomagnetic induction data should be explicable in terms of near-field scattering theory. However, if the Earth's inductive response comprises also a convective current mode similar to a linear circuit, then a more general formulation of the induction problem would be required. It is shown that the internal night-time Sq field can be attributed more easily to transient induction effects than to the global linear circuits proposed by Ashour and Price (1965).
[illegible]

0780 Scattering
A CLOSED FORM [illegible] FOR ELECTROMAGNETIC SCATTERING BY STRIPS AND 90° DIHEDRALS
A Michaeli (Electromagnetic Research Department, Armament Development Authority, P.O.B. 2250, 31021 Haifa, Israel)

The PTD (physical theory of diffraction) is applied to the high frequency scattering of a plane electromagnetic wave by a perfectly conducting strip. Closed form expressions are obtained for the far scattered field in the TE and TM cases. These expressions are continuous at grazing incidence and uniform in the overlapping transition regions. They extend the closed form results of Tiberio and Kouyoumjian from strictly grazing to nearly grazing incidence. The comparison with numerical results based on the moment method shows that these expressions furnish an excellent high-frequency approximation to the exact solution of the strip problem. The results for a strip are then used in a ray tracing analysis of the backscattering from a 90° dihedral.
Rad. Sci., Paper 3S1916

0780 Scattering
A PREDICTION METHOD FOR THE RECEIVED POWER FROM RAIN SCATTERING
J. Awaka (Kashima Branch, Radio Research Laboratories, Kashima, Ibaraki 314, Japan)

Assumptions of rainfall rate and rain attenuation being described by log-normal distributions lead to a prediction of the received power from rain scattering. Predicted values agree quite well with the 2-year experimental values of a rain scatter experiment at 14.3 GHz. (Prediction, rain scattering).
Rad. Sci., Paper 3S1908

0790 Instrumentation and Techniques (Radar Meteorology)
S-BAND RADAR DIFFERENTIAL REFLECTIVITY MEASUREMENTS IN MULTIPLE POLARIZATION PLANES ALONG SATELLITE SLANT PATHS
R. E. Marshall, T. Pratt, E. A. Manus, D. P. Stapor and J. H. Andrews. (Satellite Communications Group, Electrical Engineering Department, Virginia Polytechnic Institute and State University, Blacksburg, VA, 24060.)

A novel approach to making differential reflectivity measurements in multiple polarization planes has been proposed. This paper describes a versatile technique using a mechanical polarization switch and the systematic errors in differential reflectivity measurements which result. Initial results of simultaneous X band slant path measurements of attenuation and depolarization at 11.6 GHz and differential reflectivity measurements at 2.8 GHz using a slow polarization switch are presented. (Tropospheric propagation, radar meteorology, dual polarization, differential reflectivity).
Rad. Sci., Paper 3S1101

Exploration Geophysics

0930 Magnetic and electrical methods
RESPONSE OF A CURRENT LOOP ANTENNA IN AN INVADED BOREHOLE
W.C. Chew (Schlumberger-Doll Research, P.O. Box 307, Ridgefield, CT 06877)

The problem of the radiation of a current loop antenna in a multicylindrical medium is formulated exactly in terms of an integral. The integrand is calculated using an iterative scheme making the intergral more tenable to approximation. This closely approximates the response of a dielectric logging tool such as the deep propagation tool (DPT) or an induction tool in invaded boreholes. To gain more physical insight into the waves, an asymptotic approximation of the integral is derived. The large parameter for the validity of this approximation is the ratio of the invasion around the borehole. An iterative scheme is devised to compute systematically the approximation for an arbitrary number of cylindrical layers. The multicylindrical layer model is a good model of the invasion zone, borehole, and tool housing. The final approximation to the azimuthal electric field contains three terms. The first term resembles the response of a current loop in a homogeneous medium with electrical properties of the outermost medium or the formation. The higher order terms are improvements. The approximation is better at lower frequencies, implying that it is also good for the induction logging tool,
GEOPHYSICS, VOL. 49, NO. 1

0930 Seismic methods
THE RELATIONSHIP BETWEEN "DIRECT, DISCRETE" AND "ITERATIVE, CONTINUOUS" ONE-DIMENSIONAL INVERSE METHODS
Samuel H. Gray (Amoco Production Co., P.O. Box 591, Tulsa, OK 74102)

Two distinct approaches to solving the one-dimensional seismic inverse problem are compared. These are (1) the "direct" method of Goupillaud (1961), applied to discretely varying media, and (2) the "iterative" methods of Gjevik et al (1976), or Gray and Hagin (1982), applied to discretely or continuously varying media. These two approaches are shown to be equivalent in two important respects. First, each method can be recovered from the other (e.g., the discretized version of the direct method). Second, because of the first equivalence, each method uses the same amount of information in reconstructing a profile to a certain depth x or traveltime t into the medium. This information is the reflection data received for times less than 2t. In particular, neither approach uses the "redundant data" received after time 2T in an inversion for a profile which is known to vary only for depths which correspond to traveltime T—in this sense the methods are as economical as possible, using the minimum amount of information required to solve the idealized problem.

The key to relating the discrete, direct inversion to the continuous, iterative inversion is the Bremmer (1951) series for the reflected wave field. By using this series, it is possible to show that the equivalent inversion methods invert the same equation for the unknown acoustic impedance variations. The difference in the approaches used to solve this equation is analogous to the difference between solving a system of linear equations "directly" or "iteratively."
GEOPHYSICS, VOL. 49, NO. 1

Water Resources Research

Volume 19 Number 6 December, 1983

Particles and Fields—Ionosphere

5520 Electric fields
VELOCITY SPIKE AT THE POLEWARD EDGE OF THE AURORAL ZONE
O. de la Beaujardiere (Radio Physics Laboratory, SRI International, 333 Ravenswood Avenue, Menlo Park, CA 94025) and R. A. Heelis

Data from coordinated observations of the Chatanika incoherent-scatter radar and the Atmosphere Explorer-C satellite are examined to study the poleward edge of the auroral zone for one pass in the morning sector. A very intense, spikelike electric field is seen at the boundary between the auroral zone and the polar cap, coincident with the convection reversal. The particle-detector data are consistent with the presence of a pair of oppositely oriented potential drops parallel to the magnetic field. These potential drops are of a few hundred electron volts, and their direction is such that the precipitating electrons are accelerated on the poleward side and decelerated on the equatorward side of the electric-field spike. These observations are examined in the light of recent theoretical investigations that have shown that parallel acceleration can indeed be expected to occur in the regions of large velocity shear. The Chatanika data suggest that such spikes may occur repeatedly at the poleward edge of the diffuse aurora, but that they are confined in either time or space. (Electric field, arc, currents, auroral zone.)
J. Geophys. Res., Space, Paper 3A1839

5520 Electric Fields
THE PLASMA WAVE ENVIRONMENT OF AN AURORAL ARC: ELECTROSTATIC ION CYCLOTRON WAVES IN THE DIFFUSE AURORA
E. A. Bering (Physics Department, University of Houston, University Park, Houston, Texas, 77004)

Emissions that appear to have been electrostatic ion cyclotron (EIC) waves have been observed at low altitude in the diffuse aurora by a sounding rocket payload. The rocket was launched from Poker Flat, Alaska, at ~2030 MLT. The flight successively traversed ~70 km of the diffuse aurora, a dark region, and a quiet 40 kR auroral arc. In the diffuse aurora, peaks were observed in the power spectrum of the electric field at frequencies near the hydrogen and oxygen ion cyclotron frequencies. Doppler shift and polarization analyses have been performed using EIC wave spectrum parameters derived from linear theory. Both analyses indicated that these emissions had properties consistent with those expected for H^+ and O^+ EIC waves. Taken together, the two analyses indicated that both emission bands were due to waves propagating both up and down the field line and eastward parallel to the poleward boundary of the diffuse aurora. The large local cold plasma density and resulting large Landau damping require that the source be local. Free energy for the waves was apparently available in the 5 μA/m² downward parallel current density which was inferred from the magnetometer data. The presence of the waves indicates that this current was being carried by less than 2% of the plasma, presumably in the form of a field aligned beam of electrons with energies of a few eV.
J. Geophys. Res., Space, Paper 3A1909

5648 Ionospheric disturbances
INTERACTION OF AN ACOUSTIC WAVE OF ARTIFICIAL ORIGIN WITH THE IONOSPHERE AS OBSERVED BY VERTICAL HF SOUNDING AT TOTAL REFLECTION LEVELS
E. Blanc (Commissariat à l'Energie Atomique, Laboratoire de Détection et de Géophysique, B.P. n° 12, 91680 Bruyères-le-Châtel, France).

Interaction of a pressure wave with the ionosphere observed by vertical HF total reflection is described in terms of characteristic changes in the echo phase path, group path and amplitude. The interaction also produces distortion of the frequency modulation and envelope of the echo pulses. Observations of this interaction are presented for acoustic waves generated by ground level explosions. Experiment used Gaussian pulses at 2.411 and 5.060 MHz reflected in the E and F regions. Since the interaction lasts only a few seconds, the sounding data have been analyzed for each pulse, individually recorded at the frequency of 25 pulses per second and digitized with a group time resolution of 0.3 μs. An analysis of all the sounding parameters has been performed to determine the profile of the ionisation ripple produced by the acoustic wave in the ionosphere. Group time measurements of the pulse maxima and a sound speed model are used to retrieve gradient changes during vertical propagation of the ripple. When ionospheric curvature is not significant, the time distribution of the instantaneous frequencies within the pulse is expressed in terms of the electron density profile gradient at the reflection level and this is used to improve the reconstructed profile. The simulation results of the ripple effects on the echo group path, phase path and amplitude are compared with the experimental data and found to be in good agreement. The ripple travels in the E region at 300 m/s and in the F region at 600 m/s. It is sinusoidal and characterized by relative amplitudes of 4 and 0.5 % with wavelengths of 2 and 5 km respectively.
Rad. Sci., Paper 3S1914 12/6

5580 Wave propagation
SIMULTANEOUS OBSERVATIONS OF ELF WAVES FROM AN ARTIFICIALLY MODULATED AURORAL ELECTROJET IN SPACE AND ON THE GROUND
H.G. James (Communications Research Centre, Department of Communications, Ottawa, Canada K2H 8S2), R.L. Dowden, M.T. Rietveld, P. Stubbe and H. Kopka

Radio waves at frequencies between 525 and 5850 Hz were observed simultaneously on the ground and in the VLF receiver of the ISIS-1 spacecraft during a flight over the Max-Planck-Institut für Aeronomie ionospheric heater near Tromsø, Norway on 9 December 1981. The heater carrier frequency, 4.04 MHz, was amplitude-modulated with a set of four frequencies: 525, 1725, 2925 and 4125 Hz. The satellite detected all these fundamental frequencies plus harmonics of the 525 Hz and 2925 Hz components, caused by the nonsinusoidal modulation of the carrier. Characteristics of the signal received along the satellite track are in approximate agreement with the results of three-dimensional ray-tracing applied to a model of the ionosphere around Tromsø. The time dispersion of the signals is best fitted with an ionospheric density model based on real-time data with relatively low peak values. Observed signal levels have been transformed to power flux by using a plasma dipole theory and wave-polarization information obtained from the 3-D ray solutions. Through the use of a magnetoplasma dipole theory for the induced D/E-region current, the observed levels are found to correspond to radiation created by effective dipole currents between about 1.0 and 100 A. The geometrical optics theory also predicts two solutions for rays reaching a given satellite point near the polar limit of the reception zone, and a northern limit corresponding to a caustic surface. The frequencies of signal fades observed in this region are also predicted by the geometrical optics theory, but the fade depths are not. Simultaneous ground observations correspond to source region currents of about 1 A or less. Also the ELF waves observed on the ground have different harmonic signal ratios and much smaller fluctuations than those observed on ISIS.
J. Geophys. Res., Space, Paper 3A1752

Planetology

6510 Atmospheres of Planets
NEW EMPIRICAL MODELS OF THE ELECTRON TEMPERATURE AND DENSITY IN THE VENUS IONOSPHERE WITH APPLICATION TO TRANS-TERMINATOR FLOW
R. F. Theis (Laboratory for Planetary Atmospheres, NASA/Goddard Space Flight Center, Greenbelt, MD 20771), L. H. Brace, R. C. Elphic* and H. G. Mayr

The continuing rise of periapsis has allowed the Pioneer Venus Orbiter to encounter vast regions of the Venus ionosphere that were not sampled earlier when propulsion was being used to maintain periapsis deep in the ionosphere. We have employed the Orbiter Electron Temperature Probe measurements from the first seven Venus years (December 1978 – December 1982) to devise a new empirical model of electron temperature, T_e, and density, N_e. Departing from our earlier use of spherical harmonics to describe the solar zenith angle variations of N_e (Theis et al., 1980), we find that this more complete data set can be described better by error functions and exponentials, in solar zenith angle, and power law variations in altitude. This model represents a significant improvement over the previous models as it allows the dawn and dusk sectors to be modelled separately, providing more realistic representations of the gradients near the terminators as well as the variation of those gradients with altitude. We employ these models to perform a two dimensional solution of the momentum equation for the nightward ion flow velocities that are believed to be largely responsible for the maintenance of the nightside ionosphere. The velocities at the terminator rise from the neutral atmospheric wind velocity (~300m/sec) at 150 km to a peak velocity exceeding 2000 m/sec above 500 km, in general agreement with PVO measurements of ion drift in that region. (Models, ionosphere, Venus)
*A NAS/NRC Associate at GSFC.
J. Geophys. Res., Space, Paper 3A1842

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Geotectonics

Volume 16, Number 3

0910 Seismic methods

NORMAL INCIDENCE LAYERED SYSTEM STATE-SPACE MODELS WHICH INCLUDE ABSORPTION EFFECTS

Feraydoun Aminzadeh (Formerly University of Southern California, Los Angeles; presently Union Oil of California, Brea, CA) Jerry M. Mendel

We show how to include absorption effects in a normal incidence state-space model of a layered media system. Two models are discussed: a convolutional state-space model and a differential-delay state-space model. Extensive results are presented for the former model, whereas only formulative results are presented for the latter.

For the convolutional state-space model we develop absorption impulse responses in closed form for Gaussian and exponential absorption operators. Simulation results demonstrate that this model has the desired low-pass filtering effect of a system with absorption losses.

The differential-delay state-space model does not appear to have been applied before in the context of seismic modeling. We suggest it as a useful model.

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0910 Seismic methods

APPLICATIONS OF OPERATOR SEPARATION IN REFLECTION SEISMOLOGY

David L. Brown (Formerly Department of Geophysics, Stanford University; presently Department of Applied Mathematics, California Institute of Technology, Pasadena, CA 91125)

The principle of operator separation, a generalization of operator splitting, is applied to some problems in reflection seismology. In particular, the examples of wave-equation migration of seismic data in a three-dimensional medium and accurate depth migration in a laterally varying medium are considered in light of this theory. For the case of a stratified three-dimensional medium, the standard dimensional splitting technique used in the downward-continuation step of the migration process can be replaced with full dimensional separation. The computational implications of this result are that the wave field array need only be transposed once during the downward continuation rather than $2n$ times, where n is the number of finite-difference steps taken in the calculation. For the example of downward continuation in a laterally varying medium, the ideas of operator separation can be used to split the downward continuation operator into two parts, one that looks like the conventional downward-continuation operator for a stratified medium, and a second that represents the correction for the effects of lateral variation.

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0910 Seismic methods

COMPUTER PROCESSING OF VERTICAL SEISMIC PROFILE DATA

Myung W. Lee (U.S. Geological Survey, Box 25046, MS 960, Denver Federal Center, Denver, CO 80225) Alfred H. Balch

Vertical seismic profiles (VSP) are a powerful tool in a variety of seismic exploration situations. Only after extensive computer processing of the raw field data, however, can the full value of this tool be realized. With the help of processing, relations between important rock parameters and acoustic properties can sometimes be established and highly reliable ties from well logs to surface seismic profiles can usually be obtained.

This basic theory of the processing techniques is well known. However, the techniques used in processing standard surface seismic profiles usually must be modified to adapt them to the unique conditions associated with VSPs.

Processing procedures, and their relevance to the interpretation of VSP and surface seismic profile data, are described.

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0910 Seismic methods

LATTICE FILTERING APPLICATIONS TO DECONVOLUTION OF SEISMIC DATA

John C. Robinson (Cities Service Company, Energy Resources Group, P.O. Box 3908, Tulsa, OK 74102)

Lattice digital filtering techniques have only recently been exposed to any significant extent through the technical literature, primarily in articles not directly related to reflection seismology. The most basic "all-zero" lattice filter dates back only around a decade.

This paper first reviews current technology in adaptive lattice filtering from the standpoint of seismic deconvolution. An "all-pole" deconvolution technique is developed next; then a new "pole-zero" lattice is adapted to seismic deconvolution, and operational methodologies for its effective implementation and stabilization are developed. Some advantages of deconvolution by lattice filtering and other potential applications of lattice filters to seismic data processing are suggested.

The adaptive abilities and effectiveness of seismic deconvolution by the the three lattice types are tested and compared with stationary Wiener deconvolution. The test data are realistically nonstationary, thus allowing all three of the adaptive lattice filters to perform favorably in comparison to the nonadaptive or stationary Wiener filter.

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0990 Instruments

ANALYSIS OF ERROR DUE TO PRESENCE OF GAPS IN THE MEASUREMENT OF ROCK SAMPLES IN A COAXIAL LINE

Frank S. C. Huang (University of Houston, Department of Electrical Engineering, Houston, TX 77004) Liang C. Shen

The theory of coaxial-line-scattering-matrix method is reviewed and the theory of gap correction is developed. Discussion includes the influence due to the presence of gaps on the apparent rock property. Correction charts to correct measured complex permittivity of rock sample to its actual value are produced. These charts are useful in the interpretation of the measured data of rock properties using the coaxial-line-scattering-matrix method.

GEOPHYSICS, VOL. 48, NO. 2

0999 General or Miscellaneous

ATTENUATION AND ANISOTROPY OF CHANNEL WAVES IN COAL SEAMS

D. J. Buchanan (National Coal Board, Mining Research and Development Establishment, Ashby Road, Burton-on-Trent, Staffs, England) P. J. Jackson and R. Davis

In recent years channel-wave seismology has shown itself to be a useful aid to coal mining. Small geologic faults which interrupt a coal seam can seriously disrupt mining by modern longwall methods. Such features have been accurately predicted at distances of several hundred meters by underground seismic surveys.

The useful range of the method in a particular seam depends critically on the rate at which channel waves in the frequency range of interest (50 to 500 Hz) are attenuated during passage through the coal; when no faulting is located by a given survey, it is always important to know at what range a fault would have been detected had it been present. To this end, the attenuation characteristics must be studied.

Frequently, coal seams are highly anisotropic waveguides. Perpendicular to the bedding plane one or two "cleat" or cleavage planes exist, along which the coal is extensively cracked and jointed. Recent work by Crampin (1978, 1981) and by Hudson (1981) has shown that such systems of parallel cracks in crustal rocks lead to anisotropic propagation of body waves, with both velocity and attenuation varying considerably as a function of angle of travel through the cracked medium. The polarization of seismic energy propagating through such media can no longer be defined as simple shear or compression. It is reasonable to expect that guided channel waves in coal seams will exhibit similar properties.

A number of transmission surveys have been carried out to investigate both attenuation and anisotropy. The principal requirement for such surveys is that in-seam shot and geophone arrays be designed to provide a large range of both source-detector distance and angle of travel through the coal. Given this condition, anisotropy of group velocity can be detected by adapting Dziewonski's multiple filter analysis of single traces to transmission stacking over selected raypath angles (Dziewonski et al, 1969). Attenuation similarly can be investigated by a least-squares regression of the logarithm of the amplitude spectrum of a particular mode onto the path length.

The methods and results of these investigations are reported here, the significance of anisotropy for the collection and processing of in-seam data is discussed, and consideration is given to the type and size of errors introduced into the position of fault predictions made on the basis of an isotropic model. The equivalence of Fermat's principle and Snell's law for anisotropic raypaths results in a computationally efficient modification to enable our previously reported dynamic trace gathering (DTG) stacking procedure to be used for such data.

GEOPHYSICS, VOL. 48, NO. 2

0999 General or miscellaneous

AUTOMATED IDENTIFICATION OF ROCK BOUNDARIES: AN APPLICATION OF THE WALSH TRANSFORM TO GEOPHYSICAL WELL-LOG ANALYSIS

Eric H. Lanning (University of Washington, Geophysics Program AK-50, Seattle, WA 98195) Douglas M. Johnson

A system of orthogonal functions, known as Walsh functions, which assume only the values +1 and −1, are presented as a tool appropriate for the anlysis of well-log data. Many of the characteristics of these rectangular waveforms, such as discrete transitions in signal level, make them ideal for processing borehole data. Using the generalized Fourier transform, the basic equations for the Walsh transform and Walsh power spectrum are developed showing how the energy in a given signal is distributed among these rectangular wave components. As a first application of the Walsh transform to logging data, a method of computer-aided rock boundary identification is developed and demonstrated on a set of well logs from a continental basalt sequence. This technique provides a fast, simple yet accurate means of dividing well-log data into groups of measurements corresponding to different rock units.

GEOPHYSICS, VOL. 48, NO. 2

0999 General or miscellaneous

SEISMIC REFLECTIONS FROM A GAS-WATER CONTACT

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Using the Biot theory, we have performed calculations to show that viscous fluid flow affects seismic wave amplitudes and reflection coefficients at a gas-water boundary in a porous sand reservoir. Our formulation of the boundary value problem for fluid-filled porous rocks is applicable at all angles and follows parallel to the classical reflection and transmission problem solved by Knott, Zoeppritz, and others for two major differences between the two: (1) in the present case, we deal with the propagation of inhomogeneous waves, and (2) there are interference fluxes of energy between various types of waves. The latter exists only at an oblique incidence.

In our model, loss of seismic energy is mainly due to mode converted type II waves of Biot at the gas-water contact which propagate away from the boundary in the manner of a diffusion process at low frequencies. Both seismic energy loss and reflection coefficients are studied over a wide range of frequencies and angles of incidence. We find that for a porous unconsolidated sandstone [V_p (brine-filled) = 7214 ft/sec, V_p (gas-filled) = 4910 ft/sec, V_s=3044 ft/sec, ϕ=0.3, permeability = 1 darcy], the energy loss associated with a single gas-water boundary is approximately 2.5 percent at 100 Hz for P-waves incident at 30 degrees and that the loss increases with frequency as $f^{1/2}$. Further, at a given frequency, the loss of energy is minimal at normal incidence (1.2 percent at 100 Hz) and maximal (6 percent at 100 Hz) in the neighborhood of the critical angle (42 degrees). We find that the inelastic losses are significantly higher at the frequencies at which seismic logging tools operate (50 percent at 10 kHz near the critical angle.) As far as the amplitude reflection coefficients are concerned, we find that the effect of the fluid flow across a single gas-water boundary is to *reduce* the reflection coefficient with increasing frequency (when the wave is incident from the gas saturated rock) at all angles of incidence. In the exploration frequency band, the reduction is about 1.5-3 percent, whereas the reduction is approximately 40-50 percent in the logging frequency band.

For high frequencies (10 kHz and higher) classical interpretation breaks down, and hence it appears that for frequencies at which the seismic logging tool operates corrections should be made to the classical theory.

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0999 General or miscellaneous

ROCK DENSITY FROM BOREHOLE GRAVITY SURVEYS

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The borehole gravity meter (BHGM) is recognized as an important logging tool obtaining formation bulk density. In general, however, the difference between two gravity observations vertically separated in a well leads to an apparent and not the actual bulk density. BHGM-derived apparent densities are equal to the formation bulk densities when the instrument passes through beds which are horizontal, infinitely extended laterally, uniformly thick, and constant in density. For many applications, departures from these assumed conditions are so slight that their effects can be ignored, and the BHGM essentially yields bulk density with a large radius of investigation.

In the presence of anomalous masses, significant distortion in formation bulk density is possible. The apparent density anomaly produced in the well by an elongated, offset density contrast is proportional to the angle subtended by the density-change interface. For a density-change boundary having circular symmetry with respect to the well, the apparent density anomaly at the center of the bed is proportional to the sine of the subtended angle.

Because the distortion in bulk density is the same just above a horizontal boundary as it is just below (in the limit, at the boundary, for a normally incident well), an abrupt change in apparent density is equal to the real density change at the boundary. This change in density, termed "the Poisson jump," is independent of geometry; our ability to measure it, however, is a function of station location with respect to the geologic bodies.

Two methods are suggested for obtaining bulk densities from BHGM apparent densities: (1) by obtaining two stations just outside as well as just within the zone of interest, the Poisson jump can be approximated and added to an independent density source (e.g., the gamma-gamma log), and (2) the apparent density anomaly within the formation of interest can be derived by modeling (perhaps based on seismic or well data) and added to the BHGM-determined densities.

Thinner beds can be studied with the BHGM than generally believed, even with much greater station spacing.

GEOPHYSICS, VOL. 48, NO. 3

0999 General or miscellaneous

A LEAST-SQUARES APPROACH TO DEPTH DETERMINATION FROM GRAVITY DATA

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The present paper deals with a numerical approach to determine the depth of a buried structure from the residual anomaly. The problem of depth determination has been transformed into the problem of finding a solution of a nonlinear equation of the form $f(z) = 0$. Formulae have been derived for a sphere, vertical and horizontal cylinders, and for a vertical fault (thin plate approximation). The procedure is applied to synthetic data with and without random errors. Finally, a field example is presented in which the depth to a fault is estimated at 3.8 km and verified from drilling results.

GEOPHYSICS, VOL. 48, NO. 3

0999 General or miscellaneous

APPROXIMATE METHOD FOR DIRECT INTERPRETATION OF GRAVITY ANOMALIES CAUSED BY SURFACE THREE-DIMENSIONAL GEOLOGIC STRUCTURES

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An efficient method for direct transformation of gravity anomalies into contour lines of depth is proposed. The method is applicable for surface three-dimensional bodies whose shape may be approximated by a cone at the first step. Hypothetical and field data evaluations presented here prove the efficiency of the method.

GEOPHYSICS, VOL. 48, NO. 3

Geochemistry

1410 Chemistry of the Atmosphere

METHYL HALIDES IN AND OVER THE EASTERN PACIFIC (40°N–32°S)

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Methyl chloride, methyl bromide, and methyl iodide measurements in and over the eastern Pacific (40°N to 32°S latitude) show mean air concentrations of 633 parts per trillion (ppt), 23 ppt, and 2 ppt, and mean surface seawater concentrations of 11.5 ng/l, 1.2 ng/l, and 1.6 ng/l respectively. Long-term ambient measurements at a marine Pacific site (39°N) show an essentially unchanging background, with some indication of high concentrations of methyl bromide and methyl iodide during summertime. These oceanic data indicate a mean surface supersaturation of 275 percent, 250 percent, and 340 percent respectively for these three methyl halides. Depth profiles show that methyl halides are most abundant in the top mixed layer of the ocean. Oceanic concentrations of methyl chloride and methyl bromide are significantly correlated (linear regression coefficient of 0.85), suggesting a common source. No relationship between oceanic methyl iodide concentrations and the other two halides could be found. Coexistence of high concentrations of methyl iodide with relatively low concentrations of methyl chloride and vice versa provided no direct support for the hypothesis that chloride ion reactions with methyl iodide may be the dominant oceanic source of methyl chloride. For the eastern Pacific, mean ocean to air fluxes (in units of 10^{-7} g cm^{-2} yr^{-1}) of 13, 1, and 1 are determined for methyl chloride, methyl bromide, and methyl iodide respectively. When extrapolated to global waters, they provide an adequate source to explain the atmospheric reservoir of these organic halides. Total organic bromine and iodine measurements would suggest that methyl bromide and methyl iodide contribute predominately to the tropospheric bromine and iodine organic reservoir.

J. Geophys. Res., Green, Paper 3C0006

1410 Chemistry of the atmosphere

NONLINEAR RESPONSE OF STRATOSPHERIC OZONE COLUMN TO CHLORINE INJECTIONS

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With a reasonably complete and up to date photochemical model of the stratosphere, we find that the calculated stratospheric ozone-column response to chlorine injections is highly nonlinear. The model calculations assume that the background inorganic (or odd) chlorine, ClX, is due to CH_3Cl and CCl_4. Additional ClX is added to the stratosphere by varying input fluxes of CCl_2F_2 and CCl_3F. The sensitivity, $\Delta O_3/\Delta ClX$, of the stratospheric O_3 column to added ClX is relatively small for ClX $\lesssim$ 3 ppb or ΔClX $\lesssim$ 2 ppb; slight ozone increases with ClX are possible over a limited range of ClX if the formation of chlorine nitrate proceeds rapidly. This may have important implications for total ozone-column trend assessment. As ClX increases beyond 3 ppb, the stratospheric O_3 column decreases with ClX increasingly rapidly. This marked departure from the linearity calculated in past years is largely due to presently accepted faster rates of reaction of OH with HNO_3, HNO_4, HO_2 and H_2O_2. If stratospheric ClX increases to about 9 ppb due to continued usage of CCl_2F_2, CCl_3F and CH_3CCl_3, the stratospheric O_3 column depletion is calculated to be 6.7 to 9.0%. Principal uncertainties in these calculations, including the rate of formation of chlorine nitrate, the products of its photolysis, and the present day mixing ratio of ClX are discussed. Calculated ozone decreases due to increased H_2O concentrations are also presented.

J. Geophys. Res., Green, Paper 3C0075

1410 Chemistry of the Atmosphere

ORGANIC MATERIAL IN THE GLOBAL TROPOSPHERE

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Interest in the global tropospheric chemistry of organic materials has been growing rapidly over the past decade. In addition to a basic concern about the fundamental biogeochemical cycles of organic matter, this interest has arisen largely due to concern about the oxidant-forming potential of natural hydrocarbons, the possible importance of non-methane hydrocarbons as a source for atmospheric CO, and the role played by organic material in the formation of secondary aerosol particles. In this review we consider the information presently available on concentration distribution, sources, sinks, and atmospheric transformation reactions of organic matter in the global troposphere. The data base for tropospheric organic compounds is very small. However, it is apparent that while anthropogenic sources often dominate the atmospheric chemistry of organic material in urban and near-urban air, a key to understanding the global cycling of tropospheric organic substances is a clear understanding of the interaction of the atmosphere with the terrestrial and marine biosphere. (Troposphere, organic material, hydrocarbons, atmospheric chemistry).

Rev. Geophys. Space Phys., Paper 3R0093

1410 Chemistry of the atmosphere.

THE GLOBAL DISTRIBUTION OF ATMOSPHERIC CARBON DIOXIDE: 1. ASPECTS OF OBSERVATIONS AND MODELLING

G.I. Pearman (CSIRO Division of Atmospheric Physics, Aspendale, 3195, Australia), P. Hyson and P.J. Fraser.

A 2-dimensional global atmospheric transport model is used to relate estimated air to surface exchanges of CO_2 to spatial and temporal variations of atmospheric concentration of CO_2. This serves to illustrate the gross features of the carbon cycle and the measurement precision required of the longitudinal global observational network, if the latter is to contribute useful information to the quantitative description of the cycle.

Calculations are based on the atmospheric model coupled to a fixed, or variable depth, oceanic mixed layer. Zonally averaged air-sea fluxes of CO_2 are estimated from a relationship between flux, partial pressure, temperature and wind stress.

The result is a time dependent (pre-industrial to 1980) estimate of the meridional rates of net exchange of CO_2 with the oceans. For example, it is estimated that, at present, the equatorial oceans release a net total of 1.3 Gt of carbon into the atmosphere annually while high latitude oceans take up a net total of 4.4 Gt.

Associated with the increasing release of fossil-fuel derived CO_2 into the northern hemisphere atmosphere, the model suggests that the interhemispheric difference in concentration of CO_2 (high latitude north-high latitude south) has changed from ~-1 ppmv pre-industrially to ~+1 in 1960 and to 4-5 ppmv at present. The 1960 distribution agrees with the limited observational data available for that time. Present day observations, although provisional, are in good agreement with model estimates of the annual mean global distribution of CO_2. The influence of this changing interhemispheric distribution on the concept of the air-borne fraction of CO_2 is discussed.

The sensitivity of the mean global distribution of CO_2 to additional surface exchanges is demonstrated by modelling the hypothetical cases of a 1, 2 or 5 Gt yr^{-1} equatorial source (such as tropical deforestation) with a similar uptake by the temperate northern hemisphere forests. Such changes bring about a 20%, 40% or 100% reduction respectively, in the simulated interhemispheric concentration difference. Alternatively, the 1, 2 or 5 Gt yr^{-1} equatorial release is taken up by the global oceans. In this case, the South Pole to equatorial concentration difference increases from 3 ppmv on average to 3.5, 4.0 and 5.5 ppmv, respectively.

Taken in conjunction with presently available observations, which must be regarded as provisional, these results place constraints on the magnitude of any actual equatorial deforestation source. It is unlikely that such a source, combined with the sink, could amount to more than about 2 Gt yr^{-1}. The difficulty of establishing more precisely the magnitude of such regional exchanges is discussed in light of the model limitations and required precision of the observational network. (Carbon dioxide, carbon cycle, air-sea gas exchange)

J. Geophys. Res., Green, Paper 3C0032

1410 Chemistry of the Atmosphere

ALTITUDINAL AND TEMPORAL VARIATION OF HYDROCARBONS AND OTHER GASEOUS TRACERS OF ARCTIC HAZE

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Springtime concentrations of hydrocarbons and chlorocarbons in the arctic atmosphere (70°N, Barrow) are reported. Concentrations of the following gases were determined: acetylene (C_2H_2), ethene (C_2H_4), ethane (C_2H_6), propane (C_3H_8), benzene (C_6H_6), toluene (C_7H_8), perchloroethylene (C_2Cl_4) and trichloroethylene (C_2HCl_3). Vertical distributions of these gases were also determined on flights during May 1982. The results show that C_2Cl_4, C_2H_2, and C_2H_6 may be gaseous tracers of arctic haze. Their vertical profiles suggest that polluted air may be transported to the arctic 1-2 km above ground and perhaps also in layers higher than this level. (Trace gases, arctic haze, lifetimes)

Geophys. Res. Lett., Paper 3L0015

1410 Geochemistry (Atmospheric chemistry)

OXIDES OF NITROGEN AT TWO SITES IN NEW ZEALAND

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Oxides of nitrogen, ozone and solar UV radiation were measured at two New Zealand sites, four months at Mt. John near Lake Takapo, and one month at the New Zealand Department of Scientific and Industrial Research, Physics and Engineering Laboratory Atmospheric Station (PELAS) near Lauder. The former site proved ideal for clean-air measurements. Ozone concentrations of ~20-25 ppb, with little diurnal variation were accompanied by total nitrogen oxide (NO_y) levels frequently less than 150 ppt (parts in 10^{12} by volume). The noon NO and NO_2 data were well correlated with a slope comparable to model values. Gaseous HNO_3 was observed to be significantly above the noise level (~15 ppt) for only twenty-seven four-hour averages. For these a median of 43 ppt was obtained with a median ([NO_y]-[HNO_3])/[HNO_3] ratio of 7.5, not comparable with model values of around 1.1. This low HNO_3 may arise from the fact that the Mt. John site is downwind of a mountain range which experiences significant upwind precipitation. At PELAS site, strong diurnal variation of ozone and much larger NO_y concentrations were observed. The difference is apparently caused by local sources of nitrogen oxides and the local meteorology at the fertile valley PELAS site. (Nitrogen oxides, ozone, solar UV radiation, clean-air measurements).

Geophys. Res. Lett., Paper 3L0057

1410 Geochemistry (Chemistry of the atmosphere)

^{7}Be AND ^{210}Pb TOTAL DEPOSITION FLUXES AT NEW HAVEN, CONNECTICUT AND AT BERMUDA

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The total deposition fluxes of ^{210}Pb and ^{7}Be were determined at New Haven, Connecticut and Bermuda over approximately the same annual period in 1977-1978. The ^{210}Pb flux has remained virtually constant at New Haven from 1973 to 1978, the flux in the 1977-1978 period being 1.2 dpm/cm^2/y. The ^{210}Pb flux at Bermuda is 0.69 dpm/cm^2/y. This lower flux than expected from model calculations is due to the establishment of a blocking high pressure cell during the summer which deflects continental air. The ^{7}Be fluxes at New Haven and Bermuda are 22.7 and 17.1 dpm/cm^2/y, values consistent with western North Atlantic oceanic standing crop measurements, but higher than some other estimates. Where the difference cannot be attributed to differences in sampling it is ascribable to regional differences compatible with the oceanic data.

J. Geophys. Res., Green, Paper 2C1674

Hydrology

3175 Soil Moisture

UNSATURATED FLOW IN SPATIALLY VARIABLE FIELDS II. APPLICATION OF WATER FLOW MODELS TO VARIOUS FIELDS

Eshel Bresler (Division of Soil Physics, Institute of Soils and Water, ARO, The Volcani Center, Bet Dagan, Israel) and Gedeon Dagan

A method of modeling water flow during infiltration and redistribution has been applied to compute expectations and variances of water flow variable and of effective hydraulic properties. Two spatially variable soils with different degrees of variation have been investigated. The expectations and variances are obtained by using statistical procedure and probability density function (p.d.f.) of saturated hydraulic conductivity (K_s). An approximate solution which assumes the concept of a wetting front and uniform water content is used for the statistical procedure. A comparison of these results with data computed by a more accurate numerical solution to Richard's equation shows that approximate simplified models lead to a quite accurate value of the expectations and variances of the flow variables when the field is sufficiently heterogeneous. It is suggested that in spatially variable fields, stochastic modeling represents more realistically the actual flow phenomena and provides the main statistical moments (mean, variances) by using simplified flow models which can be used with confidence in applications. It is also shown that effective hydraulic properties may be meaningful only under very restricted and special conditions, such as steady gravitational flow. They do not exist in the general case of infiltration-redistribution. It is concluded that the traditional deterministic approach for solving the flow equation cannot be justified for solving flow problems in spatially variable fields. (Infiltration, redistribution, statistical moments, specific flux, hydraulic conductivity, numerical solution, Richard's equation, randomness, log normal distribution).

Water Resour. Res., Paper 3W0009

3175 Soil Moisture

UNSATURATED FLOW IN SPATIALLY VARIABLE FIELDS. PART 1: DERIVATION OF MODELS OF INFILTRATION AND REDISTRIBUTION

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Models of water flow in the upper soil layer of spatially variable fields are developed. Field variability is assumed to take place in the horizontal plane. The saturated hydraulic conductivity is assumed to be a random variable of lognormal distribution, and head suction and moisture content are related to it by simple analytical relationships. The aim of the study is to derive the expectation and variances of the moisture content, suction head, hydraulic conductivity and water flux as functions of depth and time for infiltration and redistribution. Toward this aim a simplified solution of vertical flow in a homogeneous column based on the concept of moving front, is developed. The statistical procedure for using this solution in a spatially variable field is outlined. (Log normal distribution, hydraulic conductivity, specific flux, infiltration, redistribution, statistical moments, randomness, Richard's equation).

Water Resour. Res., Paper 3W0008

3180 Water quality

UNSATURATED FLOW IN SPATIALLY VARIABLE FIELDS III. SOLUTE TRANSPORT MODELS AND THEIR APPLICATION TO TWO FIELDS

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An approximate model of salt transport in a spatially variable field during infiltration and redistribution is presented. The water flow is assumed to be vertical and both water pore-velocity and depth of wetting front change in the horizontal plant due to the variability of soil hydraulic properties. The salt transport in the vertical profile is computed by using an approximate, closed form solution, of the convection-dispersion equation, with the value of the dispersivity increasing from zero to its maximum (3 cm) as the front propagates downward. The concentration profiles vary in the horizontal plane because of the variation of water flow variables. The expectation value and the variance of the concentration are computed as function of depth and time for two soils, one of large variability, and the second, of lesser variability. The results are compared with those based on a numerical simulation of the water flow and salt transport, as well as with those pertaining to an equivalent, deterministic, uniform soil (for the expected value). It is shown that the approximate model yields quite accurate results when compared with the numerical simulations for the field of large variability, whereas some differences are present for the more uniform one. The results for the expected value, based on the traditional approach of replacing the variable field by an equivalent uniform one, include a much larger error. The main conclusion is that in spite of the apparent complexity, the statistical moments of salt concentration in a spatially variable field can be determined by using simple flow models. (Transport modeling, hydraulic properties, dispersivity, statistical moments, randomness).

Water Resour. Res., Paper 3W0010

3199 General (Applications of Surface Soil Moisture Information)

ESTIMATING PROFILE WATER STORAGE FROM SURFACE ZONE SOIL MOISTURE MEASUREMENTS UNDER BARE FIELD CONDITIONS

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Studies in remote sensing of soil moisture indicate that the depth of the soil for which moisture information is obtained is very shallow. Therefore, in order to enhance the utility of the remotely sensed soil moisture measurements, procedures and models are needed which will relate the profile moisture conditions to those of the surface zone. A linear regression approach was used to estimate profile water storage from the storage in the surface zone. For a given thickness of the surface zone, the correlations between the surface-zone and profile water storages decreased as the profile depth increased; for a given profile depth, these correlations increased as the surface zone thickness increased. In general, the correlations were higher for irrigated corn fields than for bare fields. Results show that the profile depth for which water storage can be predicted from surface zone soil moisture data depends on the thickness of the surface zone, the cultural condition of the field, and the coefficient of determination considered adequate. An alternative procedure to estimate water storage in a deep profile under bare field conditions is based on the assumption that change in profile water storage over a period of time equals net surface flux over the same time. Surface fluxes are computed from surface-zone soil moisture data and hydrologic properties of the soil. The regression approach is used to estimate near-surface moisture gradients given only an average surface-zone moisture value. In a simulation study, net surface fluxes very nearly equaled changes in water storage of a 2.25-m-deep profile. For a field-measured data set computed surface fluxes based on surface-zone moisture data and those measured by a weighing lysimeter showed good overall agreement. (Surface flux, evaporation, surface zone moisture, profile water budget).

Water Resour. Res., Paper 2W1941

Meteorology

3710 Boundary layer structures and processes

A MODEL OF THE ATMOSPHERIC BOUNDARY LAYER OVER THE MARGINAL ICE ZONE

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A one-layer, primitive equation model is presented for the atmospheric boundary layer over the marginal ice zone (MIZ) which simulates the slow rate of inversion growth and rate of warming of the boundary layer seaward of an ice edge for off-ice winds observed on two cruises in the Bering Sea by the NOAA *R/V Surveyor*. The horizontal temperature gradient in the boundary layer due to the oceanic heat flux seaward of an ice edge only slightly increases (2%) the wind speed at the edge because the induced pressure gradient is largely compensated by the pressure gradient due to the change in inversion height. Wind velocity in the shallow boundary layer over the MIZ during off-ice winds is, however, very sensitive to changes in surface roughness. When an inversion base of 450 m is specified over the interior of the ice and drag coefficients for smooth ice, a 30-km-wide, rough marginal ice zone, and an unstable surface layer over the ocean are used, the model shows a decrease in wind speed of 10% at the windward side of the MIZ and a 10% increase in wind speed and a 17% increase in wind stress in the transition from rough ice to open water beginning 5 km interior to the ice edge with a maximum in speed at 40 km seaward of the edge. These results suggest an atmospheric mechanism for rafting at the windward side of the marginal ice zone, divergence of the ice at the edge and ice band formation seaward of the edge.

J. Geophys. Res., Green, Paper 3C0076

3715 Chemical composition and chemical interactions

THE DISTRIBUTION AND ANNUAL CYCLE OF OZONE IN THE UPPER STRATOSPHERE

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Study of the global distribution of upper stratospheric ozone derived from backscatter ultraviolet (BUV/SBUV) instruments on the Nimbus 4 and 7 satellites reveals the following characteristics for the period June 1970 through May 1972 plus portions of 1978 and 1979. At pressures less than 5 mb a local mid-latitude maximum in the ozone mixing ratio develops in autumn and persists through the winter season in both hemispheres. However, by a pressure of 10 mb the seasonal trend has reversed with mid-latitude summer values exceeding those in winter. The largest ozone mixing ratios in a global sense occur at tropical latitudes between pressures of 7 and 9 mb. The general character of this pattern repeats from year-to-year, although differences in detail exist, especially in winter. This interannual variability in ozone increases the difficulty in extracting small long-term trends from the available data base. The overall seasonal pattern revealed by the measurements is in accord with photochemical model predictions which include the annual variation in temperature and solar illumination.

J. Geophys. Res., Green, Paper 3C0065

3715 Chemical Composition

EVIDENCE FOR QUASI-PERIODIC COMPONENTS IN DOBSON NETWORK TOTAL OZONE RECORDS

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Power spectrum analysis has been applied to the total ozone time series at each of a sample of Dobson stations with records of more than 15 years in the interval 1957 to 1981. The distributions of strongly periodic or quasi-periodic signals show distinct features at periods of 3.5-4.0 years, 27 months, 21 months, and 11.5 months. Several stations show two or more such features in the same time series. Possible geophysical implications are discussed. (Ozone, Quasi-Biennial Oscillation)

J. Geophys. Res., Green, Paper 3C0003

3715 Chemical Composition and Chemical Interactions

AQUEOUS OXIDATION OF SO_2 BY HYDROGEN PEROXIDE

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The aqueous oxidation of S(IV) by H_2O_2 is one of the principal paths of acid formation in the atmosphere. Several investigators have measured the rate constant for the reaction: $H_2O_2(a) + S(IV)(a) \rightarrow H_2SO_4(a)$, as a function of temperature and pH. The reactant concentrations used, however, were several orders of magnitude greater than those found in precipitation or cloud particles. We have measured the rate constant at more typical environmental concentrations using a different analytical technique in which excess S(IV) (10^{-4} to 10^{-5}M) was reacted with H_2O_2 (~10^{-7}M). We followed the decay in H_2O_2 concentration with time using a H_2O_2 luminol-chemiluminescent instrument. The lower reactant concentrations we use obviate the use of buffers at our working pH range of 4.0 to 5.8.

Our measurements of the S(IV)-H_2O_2 rate constant were in substantial agreement with the previous measurements. We noted a first order dependence in the rate constant with hydrogen ion concentration and at 22°C find our results can be represented by $k = (8.03 \pm 0.18) \times 10^7 [H^+]$ dm^3 mole^{-1} s^{-1} when the pH is between 4.0 and 5.8.

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J. Geophys. Res., Green, Paper 2C1861

3720 Climatology

THE GEOLOGIC RECORD OF CLIMATIC CHANGE

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This paper reviews the principal results from paleoclimate studies, and includes background material slanted toward climate modelers. The inferred temperature history during the last 4.6 billion years indicates major changes in the components of the Earth's climate system. A secular change in global insolation receipt is due to a 20-30% increase in solar luminosity since the formation of the earth. A CO_2-H_2O greenhouse effect may have offset the lower luminosity during early earth history. Inferred fluctuations of global temperature have occurred over a broad range of time scales. On time scales of 10^6-10^8 years paleogeographic factors (e.g., continental drift and sea level changes) have contributed significantly to temperature changes associated with transitions between nonglacial and glacial states. Preliminary modeling efforts indicate that additional factors (e.g., CO_2, changes in atmospheric circulation) must also be considered in order to explain the origin of nonglacial climates.

The origin of polar ice caps may result from ocean circulation changes that were caused by plate tectonic processes. Fluctuations of ice volume on a time scale of 10^3-10^5 years correlate with insolation variations caused by orbital perturbations. Feedback interactions within the land-sea-air-ice system (e.g., ocean circulation changes and bedrock dynamics) have been responsible for a significant modulation of the orbital signal. Ice ages may be due to orbitally-induced temperature changes superimposed on a global cooling of terrestrial origin. (Paleoclimatology, review).

Rev. Geophys. Space Phys., Paper 3R0092

3735 Electrical Phenomena

BRIEF REPORT: CORONA-POINT MEASUREMENTS IN A THUNDERCLOUD AT LANGMUIR LABORATORY

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A meteorological radiosonde, modified by the attachment of vertically oriented, pointed, metal rods and associated instrumentation, was released beneath a thundercloud at Langmuir Laboratory, New Mexico. In addition to information on temperature and winds, the instrument provided an estimate of the vertical component of the cloud electric field by measurement of corona current induced in the rods. Charge volumes inferred from the sounding were: (1) negative charge at 6.6 km MSL (temperature -12° C) where northwesterly winds apparently advected the charge toward the cloud's most intense precipitation echoes; (2) positive charge at 11.6 km MSL (-50° C) where the winds flowed northward into the cloud's anvil; (3) a 200 m thick screening layer of negative charge at the cloud's upper surface; and (4) a small, concentrated region of charge near the cloud base. These charged regions were evident in volumes of low precipitation intensity (log Z $\lesssim$ 1.5), which were well away from the storm's convective center. (Thunderstorms, cloud electricity, corona, electric fields, lightning.)

J. Geophys. Res., Green, Paper 3C0036

3735 Electrical phenomena

ACOUSTIC AND ELECTRIC SIGNALS FROM LIGHTNING

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Observations of infrasound apparently generated by the collapse of the electrostatic field in the thundercloud, are presented along with electric field measurements and high frequency thunder signals. The frequency of the infrasound pulse is about 1 Hz and the amplitude a few microbars. The observations seem to confirm some of the theorical predictions of electrostatic sound by earlier workers. The signal is predominated by a compressional phase and seems to be beamed vertically. Calculation of the parameters of the charged region using the infrasound signal give reasonable values. (Infrasound, electrostatic sound,thunder).

J. Geophys. Res., Green, Paper 3C0074

3736 Electrical phenomena

LIGHTNING AND PRECIPITATION IN A SMALL MULTICELLULAR THUNDERSTORM.

D.E. Proctor (National Institute for Telecommunications Research, P.O. Box 3718, Johannesburg 2000 Republic of South Africa).

Radio images of twenty six consecutive lightning flashes are described in relation to radar pictures of the storm. These flashes all started in two vertical turrets where reflectivity factors exceeded 25 dBZ. Four large cloud-flashes extended almost horizontally to pervade an almost horizontal plume or low-level anvil, and ground-flashes occurred on the opposite side, in the propagating flank of this storm, which produced hail. Most of the lightning occurred between the 3 km and 5 km levels. Flashes originated at heights that ranged from 3.1 km AGL (-6°C) to 5 km AGL B- 16°C) and they began at a mean height of 3.95 km where the environmental air temperature was -10°C. Recorded electric field-changes showed that the lightning discharged negative electricity, and we infer that negative charge had accumulated at these heights in the vertical turrets, and that cloud-flash paths had been influenced by positive charge that had accumulated in the plume. The total length of lightning channels that formed during the three-minute interval chosen for this study was 430 km. Measurements of electric field-change were used to estimate totals of 390 Coulombs and 43 coulombs that had been discharged in 180 seconds from two cells whose volumes (enclosed by 30 dBZ surfaces) were 157 and 80 cubic kilometers respectively. We describe three stepped leaders which produced electric field-changes of the type which Clarence and Malan (1957) first called a BIL-type. A continuing current that flowed along a cloud-flash is also discussed. (Lightning techniques, storm structure, sferics).

J. Geophys. Res., Green, Paper 2C1928

3755 Interaction of atmosphere with electromagnetic waves

PARAMETERIZATION OF CARBON DIOXIDE 15 μm BAND ABSORPTION AND EMISSION

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A parameterization scheme for carbon dioxide 15 μm band absorption and emission is developed based on the line-by-line transmittance data presented by Fels and Schwarzkopf (1981). We derive two polynomial equations to represent the broadband emissivity as functions of the temperature and pressure corrected path length. A detailed error analysis has been performed and the root mean square errors are shown to be on the order of 5% and 7.5% for the lower and upper atmosphere cases, respectively. Cooling rates calculated from the emissivity parameterization approach show errors within about 5% when they are compared with those computed from exact line-by-line integrations. (Carbon dioxide, radiation parameterization, carbon dioxide IR absorption).

J. Geophys. Res., Green, Paper 3C0004

3770 Particles and aerosols

LIDAR AND BALLOON-BORNE PARTICLE COUNTER COMPARISONS FOLLOWING RECENT VOLCANIC ERUPTIONS

D. J. Hofmann (Department of Physics and Astronomy, University of Wyoming, Laramie, Wyoming, 82071), J. M. Rosen, R. Reiter, and H. Jäger

Balloon-borne particle counter measurements at Laramie, WY (41°N) are used to calculate the expected lidar backscatter at 0.694 μm wavelength from July, 1979 to February, 1982, a period which included at least four detectable perturbations of the stratospheric aerosol layer due to volcanic eruptions. These calculations are compared to lidar measurements conducted at Garmisch-Partenkirchen (47.5°N) during the same period. While the agreement is generally good using only the main mode in the particle size distribution (radius ∿ 0.07 μm), during approximately the first six months following a major volcanic eruption, a measured secondary mode near 1 μm radius, when included, improves agreement. Calculations of the expected backscatter at 25-30 km reveal that substantial numbers of particles diffuse into this high altitude region about 7 months after a major eruption and these particles should be taken into account when normalizing lidar at these altitudes. (Aerosols, Lidar, Stratosphere, Volcanic eruptions).

J. Geophys. Res., Green, Paper 3C0101

3770 Aerosols (Volcanic Increase)

ENORMOUS INCREASE OF STRATOSPHERIC AEROSOLS OVER FUKUOKA DUE TO VOLCANIC ERUPTION OF EL CHICHON IN 1982

M. Hirono (Department of Physics, Kyushu University Fukuoka, 812, Japan) and T. Shibata

Large increases of stratospheric aerosol particles caused by the eruption of Mexican volcano El Chichon in early April 1982 were observed by a Yag lidar system at two wavelengths (1.06 μm and 0.53 μm)over Fukuoka for three months since April 18. Most of the observations show high concentrations of aerosols in the altitude regions from 15 to 33 km, with highest concentrations between 21 and 30 km. The aerosol optical thickness at 0.55 μm is about 0.1 − 0.3; this is about 10 to 30 times the maximum monthly mean values that were observed after the Mt. St. Helens event in 1980.

The mean radius of aerosols in the densest part of the El Chichon cloud is estimated to be approximately 0.1 μm. This estimate is based on the slow settling velocity of the peak of the cloud and from information obtained by comparison of the two-wavelength lidar returns.

A significant impact of the presence of the cloud on the climate through variations of atmospheric circulation is suggested. (Lidar, stratosphere, volcanic aerosol).

Geophys. Res. Lett., Paper 3L0058

3770 Particles and Aerosols

UNUSUAL BEHAVIOR IN THE CONDENSATION NUCLEI CONCENTRATION AT 30 Km, J.M. Rosen (Dept. of Physics and Astronomy, University of Wyoming, Laramie WY 82071) and D. J. Hofmann.

The results obtained with an improved balloon borne condensation nuclei (cn) counter that is capable of operating to altitudes of at least 30 km are presented. Of major interest is the appearance of a quasi-annual variation near 30 km which could be described by a sudden concentration increase of unusually small particles occurring in the winter or spring followed by a one to three month decay period to background levels. The magnitude of the variation has increased dramatically following the recent generally higher levels of volcanic activity affecting the lower stratosphere. Several potential explanations for the event are considered, but none appear entirely satisfactory or complete at the present time. The explanation with the fewest drawbacks would attribute the production and growth of the new cn to a highly supersaturated H_2SO_4 vapor layer generated by any one of several proposed processes in the upper high latitude stratosphere.

J. Geophys. Res., Green, Paper 3C0114

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